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Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Data

SECTION I. MILK AND FOOD

Milk Surveillance, September 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations.

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

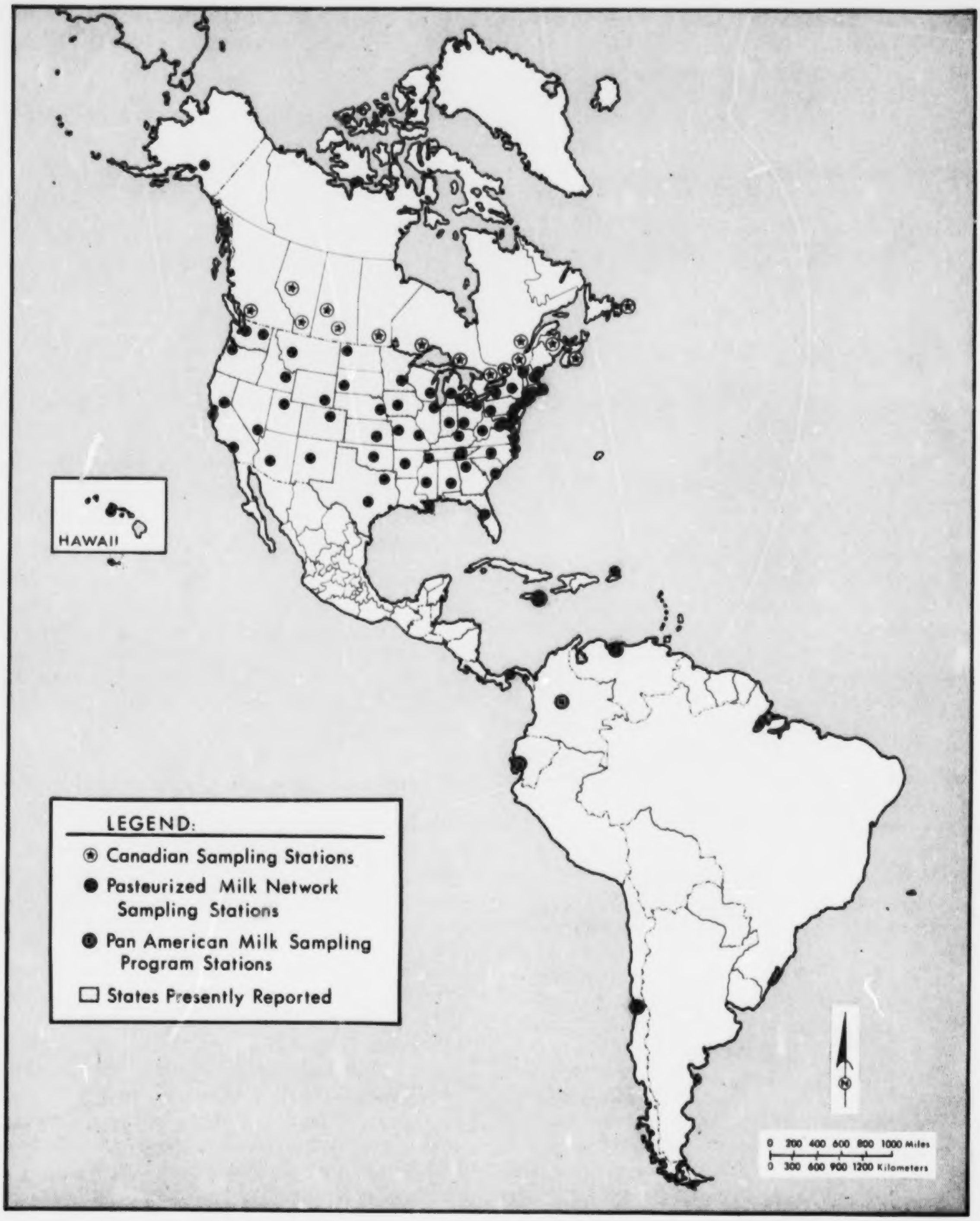
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
N

Figure 1. Milk sampling networks in the Western Hemisphere

2

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ) for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reported in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131:	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137:	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89:	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90:	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

for one analysis, while others carry out their analyses more often than one a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels<100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations

Table 2. Concentrations of radionuclides in milk for September 1973 and 12-month period, October 1972 through September 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	5
Alaska:	Palmer [c]	P	NA	4	0	1
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	NA	10	0	2
Calif:	Los Angeles [c]	P	NA	0	0	0
	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	10	10	0	7
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	0	1	0	1
	Mendocino	P	2	2	0	8
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	0	2
	Shasta	P	0	2	0	3
	Sonoma	P	0	2	0	2
Colo:	Denver [c]	P	NA	2	0	0
	East	R	NS	NA	NS	14
	Northeast	R	NS	NA	NS	0
	Northwest	R	NS	NA	NS	3
	South Central	R	NS	NA	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NS	NA	NS	2
	West	R	NS	NA	NS	0
Conn:	Hartford [c]	P	NA	4	0	4
	Central	P	NA		NA	
Del:	Wilmington [c]	P	NA	6	0	3
D.C:	Washington [c]	P	NA	4	0	1
Fla:	Tampa [c]	P	NA	4	29	30
	Central	R	7	5	23	29
	North	R	NA	7	10	12
	Northeast	R	5	6	33	32
	Southeast	R	7	5	49	46
	Tampa Bay area	P	4	5	27	29
	West	R	8	8	14	9
Ga:	Atlanta [c]	P	NA	4	0	6
Hawaii:	Honolulu [c]	P	NA	1	0	0
Idaho:	Idaho Falls [c]	P	NA	3	0	0
Ill:	Chicago [c]	P	NA	5	0	2
Ind:	Indianapolis [c]	P	NA	5	0	3
	Central	P	5	6	0	8
	Northeast	P	6	5	0	9
	Northwest	P	7	7	0	8
	Southeast	P	6	6	0	6
	Southwest	P	8	7	0	9
Iowa:	Des Moines [c]	P	NA	5	0	0
	Des Moines	P	4 (3)	5	0 (3)	0
	Iowa City	P	7	5	0	0
	LeMars	P	NS	4	NS	2
	Little Cedar	P	NS	7	NS	0
Kans:	Wichita [c]	P	NA	5	0	0
	Coffeyville	P	7	8	0	7
	Dodge City	P	6	5	0	6
	Falls City, Nebr	R	8	7	0	5
	Hays	P	6	7	0	5
	Kansas City	P	6	6	0	7
	Topeka	P	5	7	0	6
	Wichita	P	6	7	0	6
Ky:	Louisville [c]	P	NA	5	0	1
La:	New Orleans [c]	P	NS	8	NS	1
Maine:	Portland [c]	P	NA	6	18	19
Md:	Baltimore [c]	P	NA	6	0	5
Mass:	Boston [c]	P	NA	6	0	14
Mich:	Detroit [c]	P	NA	6	0	2
	Grand Rapids [c]	P	NA	8	0	1
	Bay City	P	NS	7	NS	0
	Charlevoix	P	4	6	3 (4)	3
	Detroit	P	7	5	0	0
	Grand Rapids	P	10	6	12	3
	Lansing	P	11	7	0 (2)	3
	Marquette	P	8	8	7 (2)	9
	Monroe	P	19	7	0	0
	South Haven	P	16	8	0 (4)	3
Minn:	Minneapolis [c]	P	NA	7	0	3
	Bemidji	P	7	7	0	13
	Duluth	P	16	16	14	19
	Fergus Falls	P	3	6	0	0
	Little Falls	P	20	17	32	27
	Mankato	P	5	4	0	0
	Marshall	P	3	4	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1973 and 12-month period, October 1972 through September 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:	Minneapolis	P	11	9	0	0
	Rochester	P	7	7	0	0
Miss:	Jackson [c]	P	NA	8	0	7
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	6	0	1
Mont:	Helena [c]	P	NA	2	0	0
Nebr:	Omaha [c]	P	NA	3	0	0
Nev:	Las Vegas [c]	P	NA	3	0	0
N.H:	Manchester [c]	P	NA	7	0	8
N.J:	Trenton [c]	P	NA	6	0	3
N. Mex:	Albuquerque [c]	P	NS	0	NS	0
N.Y:	Buffalo [c]	P	NA	5	0	3
	New York City [c]	P	NA	6	0	4
	Syracuse [c]	P	NA	6	0	2
	Albany	P	4	4	0	0
	Buffalo	P	4	5	0	6
	Massena	P	NA	5	0	0
	New York City	P	8	7	0	0
	Syracuse	P	NA	5	0	0
N.C:	Charlotte [c]	P	NA	7	14	6
N. Dak:	Minot [c]	P	NA	7	0	0
Ohio:	Cincinnati [c]	P	NA	5	0	2
	Cleveland [c]	P	NA	6	0	2
Okla:	Oklahoma City [c]	P	NA	3	0	0
Oreg:	Portland [c]	P	NA	4	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	0	2
	Pittsburgh [c]	P	NA	8	0	5
	Dauphin	P	6	4	0	1
	Erie	P	6	6	0	0
	Philadelphia	P	4	4	0	2
	Pittsburgh	P	8	6	0	1
R.I:	Providence [c]	P	NA	5	0	6
S.C:	Charleston [c]	P	NA	6	0	7
	Chapin	R	8	8	12	12
	Clemson	R	NS	7	NS	6
	Columbia	R	NS	7	NS	10
	Fairfield	R	6	7	18	14
	Hartsville-02	R	NS	7	NS	12
	Hartsville-03	R	NS	17	NS	16
	Lee County	R	NS	8	NS	17
	Oconee County	R	NS	8	NS	7
	Pickens	R	NS	7	NS	5
	Williston	R	NS	7	NS	14
	Winnsboro	R	7	8	12	16
S. Dak:	Rapid City [c]	P	NA	5	0	1
Tenn:	Chattanooga [c]	P	NA	6	0	4
	Knoxville [c]	P	NA	NA	0	0
	Memphis [c]	P	NA	6	0	2
	Chattanooga	P	7	7	0	4
	Clinton	R	9	6	0 (2)	5
	Fayetteville	R	NS	7	NS	5
	Kingston	R	10	7	0	0
	Knoxville	P	7	5	0 (2)	2
	Lawrenceburg	R	NS	6	NS	4
	Nashville	P	NS	5	NS	2
	Pulaski	R	7	6	0 (2)	0
	Sequoyah	R	NS	8	NS	0
Tex:	Austin [c]	P	NA	0	0	0
	Dallas [c]	P	NA	4	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	NA	3	0	1
Vt:	Burlington [c]	P	NA	5	0	7
Va:	Norfolk [c]	P	NA	5	0	3
Wash:	Seattle [c]	P	NA	2	0	0
	Spokane [c]	P	NA	4	0	0

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for September 1973 and 12-month period, October 1972 through September 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	0
	Longview	R	3	3	0	2
	Sandpoint, Idaho	R	4	5	0	1
	Skagit County	R	3	5	0	1
W. Va:	Charleston [c]	P	NA	6	0	3
Wisc:	Milwaukee [c]	P	NA	5	0	2
Wyo:	Laramie [c]	P	NA	1	0	1
CANADA:						
Alberta:	Calgary	P	4	5	11	9
	Edmonton	P	5	5	0	13
British Columbia:	Vancouver	P	5	5	14	14
Manitoba:	Winnipeg	P	4	5	NS	
New Brunswick:	Moncton	P	7	7	11	9
Newfoundland:	St. John's	P	21	14	NS	
Nova Scotia:	Halifax	P	8	7	8	11
Ontario:	Ottawa	P	2	5	5	6
	Sault Ste. Marie	P	8	9	18	17
	Thunder Bay	P	4	7	NS	
	Toronto	P	3	3	NS	
	Windsor	P	2	2	4	6
Quebec:	Montreal	P	5	5	NS	
	Quebec	P	7	8	12	14
Saskatchewan:	Regina	P	3	5	5	8
	Saskatoon	P	6	6	NS	
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NS	0	NS	8
Chile:	Santiago	P	0	1	0	1
Colombia:	Bogota	P	0	1	0	0
Ecuador:	Guayaquil	P	0	1	0	0
Jamaica:	Montego Bay	P	NS	3	NS	25
Puerto Rico:	San Juan [c]	P	NA	1	0	2
Venezuela:	Caracas	P	0	1	0	2
PMN network average [d]			0	4	1	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

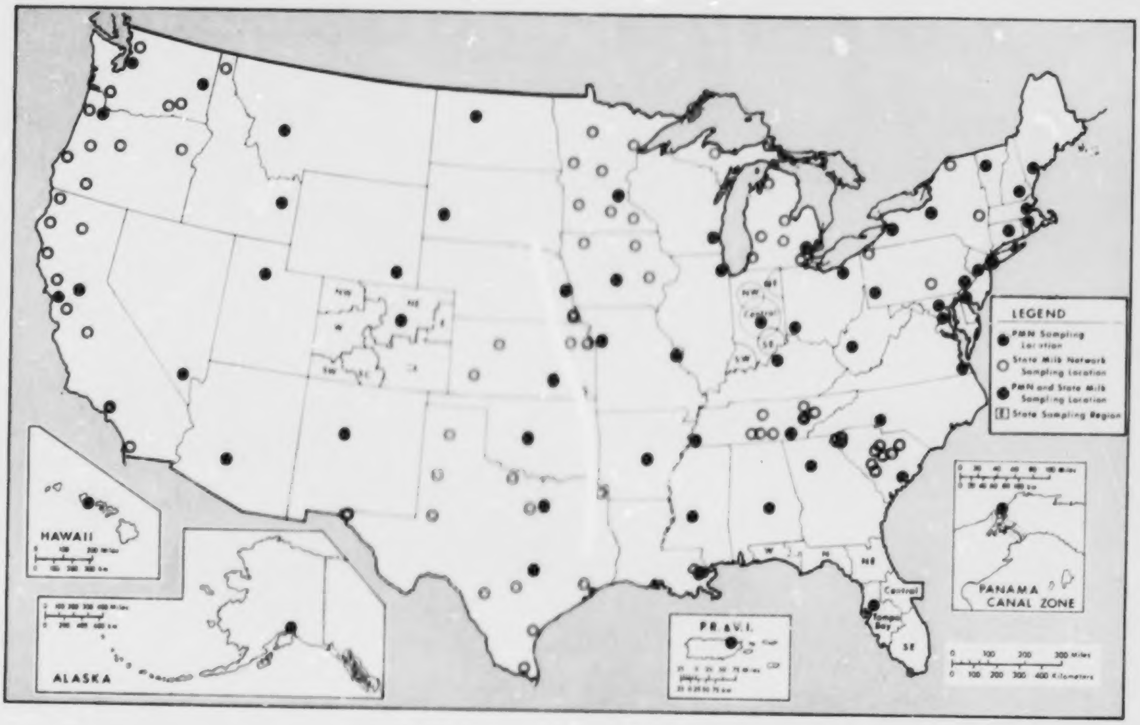

Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for September 1973 and the 12-month period, October 1972 to September 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for September 1973 were below the respective practical reporting level, except for strontium-89 at Guayaquil which was 6 pCi/liter and at Bogota, which was 7 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for September 1973 and the highest 12-month average was 17 pCi/liter (Little Falls, Minn. and Hartsville–03, S.C.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 49 pCi/liter in the United States for September 1973, and the highest 12-month average was 46 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

8

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and
Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Unit
Health Services Division
Washington Department of
Social and Health Services

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D. C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network, September 1973

National Environmental Research Center-
Las Vegas
Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV) consists of 24 routine and 2 alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected

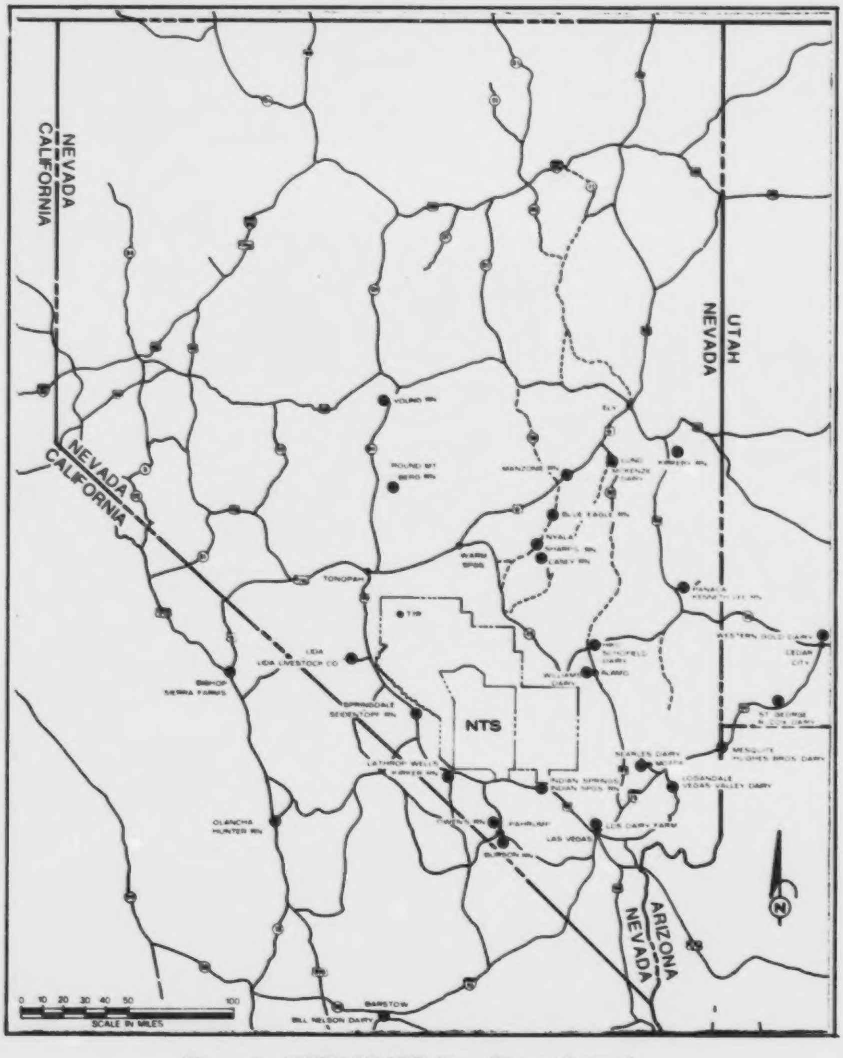

Figure 1. NERC-LV Milk Surveillance Network

areas is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports.*

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas. Nev.

Results

The analytical results of all milk samples collected in September 1973 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma emitting fission products were identified by gamma spectrometry in any of the samples collected in September. Levels of tritium near the MDA for this radionuclide (~200 pCi/liter) were also measured by liquid scintillation counting techniques. The highest concentration of tritium during September was 1 000 ± 390 pCi/liter.

Table 1. Milk surveillance results, September 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Creamery	19	11	<10	NA	NA	NA
Hinkley:						
Bill Nelson Dairy	17	12	<10	NA	NA	NA
Olancha:						
Hunter Ranch	NS					
Nevada:						
Alamo:						
Williams Dairy	4	12	<10	NA	NA	NA
Austin:						
Young's Ranch	11	13	<10	NA	NA	1000 ±390
Currant:						
Blue Eagle Ranch	13	13	<10	NA	NA	NA
Manzonie Ranch	11	13	[c] <100	NA	NA	NA
Hiko:						
Schofield Dairy	4	12	<10	NA	NA	320 ±250
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	10	12	<10	NA	NA	<250
Lathrop Wells:						
Kirker Ranch	13	13	<10	NA	NA	NA
Lida:						
Lida Livestock Company	3	13	<10	NA	NA	NA
Logandale:						
Vegas Valley Dairy	11	12	<10	NA	NA	NA
Lund:						
McKenzie Dairy	12	12	<10	NA	NA	<380
Mesquite:						
Hughes Bros. Dairy	11	12	<10	NA	NA	<380
Moapa:						
Searles Dairy	11	12	<10	NA	NA	NA
Nyala:						
Sharp's Ranch	11	13	[c] <100	NA	NA	530 ±380
Pahrump:						
Owens Ranch	12	13	<10	NA	NA	NA
Panaca:						
Kenneth Lee Ranch	6	13	<10	NA	NA	NA
Round Mountain:						
Berg Ranch	11	13	<10	NA	NA	NA
Shoshone:						
Kirkeby Ranch	NS					
Springdale:						
Seidentopf Ranch	13	13	<10	NA	NA	NA
Utah:						
Cedar City:						
Western Gold Dairy	12	12	<10	NA	NA	NA
St. George:						
R. Cox Dairy	11	12	<10	NA	NA	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).

[b] Two-sigma counting error provided when available.

[c] Small sample size increased minimum detectable activity.

NA, no analysis.
NS, no sample.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Institutional Diet	January–March 1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1 000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	January–December 1972	December 1973
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs,[1] September 1973

National Environmental Research Center-
Las Vegas
Environmental Protection Agency

The Water Surveillance Network, operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from

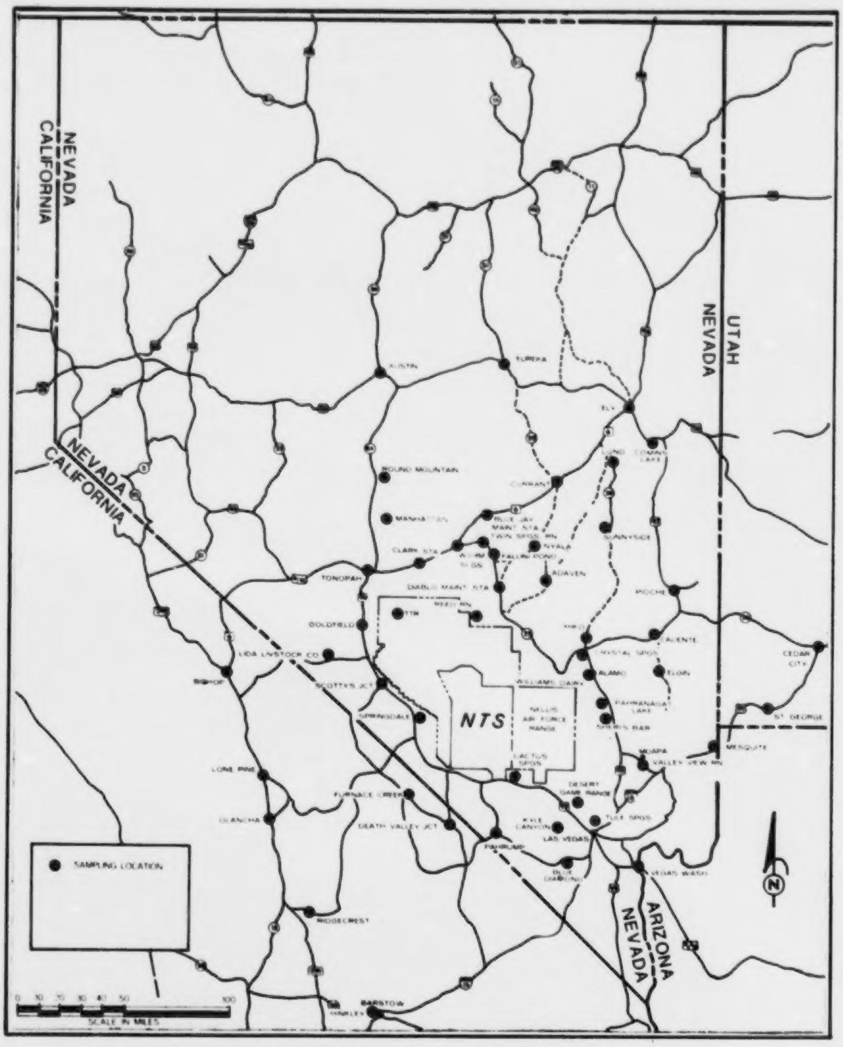

Figure 1. NERC-LV Water Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Table 1. Water surveillance results, September 1973

Location	Date collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	19	23	<1.5	<3.4	NA
Death Valley Junction:					
Lila's Cafe	14	23	<4.3	5.8±3.7	440±380
Furnace Creek:					
Pond	14	21	<3.7	8.5±3.8	NA
Visitor's Center	14	27	<3.0	6.0±3.6	NA
Hinkley:					
Bill Nelson Dairy	17	23	6.7±5.4	4.9±3.6	NA
Lone Pine:					
Forest Service Ranger Station	18	24	<1.7	<3.4	NA
Olancha:					
Haiwee Reservoir	18	21	6.2±4.0	4.9±3.5	NA
Ridgecrest:					
City Hall	17	23	<2.7	<3.4	NA
Nevada:					
Adaven:					
Canfield Ranch	11	22	3.3±2.9	<3.3	NA
Alamo:					
Pahranagat Lake	4	21	22 ±8.8	24 ±4.8	NA
Sheri's Bar	4	23	<3.0	<3.5	NA
Williams Dairy	4	23	<3.8	12 ±4.1	NA
Austin:					
Nevada National Bank	11	27	19 ±5.7	5.1±3.5	NA
Blue Diamond:					
Post Office	12	23	<2.5	<3.4	<380
Blue Jay Highway:					
Maintenance Station	12	23	<2.9	<3.4	NA
Cactus Springs:					
Mobil Service Station	11	27	<2.0	<3.3	<270
Caliente:					
Agricultural Extension Station	5	23	6.3±4.0	<3.5	NA
Clark Station:					
Five Mile Ranch	12	27	<2.2	6.1±3.6	NA
Currant:					
Currant Ranch Cafe	12	27	5.7±3.8	<3.4	NA
Diablo:					
Highway Maintenance Station	10	23	<2.1	5.2±3.5	NA
Reed Ranch	4	21	28 ±8.4	3.6±3.5	NA
Elgin:					
Water tower	6	23	4.0±2.7	6.4±3.6	NA
Ely:					
Chevron Service Station	13	24	<2.3	<3.4	NA
Comins Lake	13	21	10 ±5.6	27 ±4.7	NA
Eureka:					
Highway Maintenance Station	1	24	5.2±3.9	4.1±3.6	NA
Goldfield:					
Chevron Service Station	4	23	<3.8	<3.6	NA
Hiko:					
Crystal Springs	4	27	5.3±3.7	6.3±3.7	NA
Schofield Dairy	4	23	33 ±9.7	27 ±4.8	NA
Las Vegas:					
Craig Ranch Golf Course	10	23	4.7±3.5	<3.6	<250
Desert Game Range	11	23	2.8±2.6	<3.3	460±270
Lab II NERC	10	24	<4.6	7.1±3.9	730±260
Lake Mead Vegas Wash	10	21	<3.9	4.6±3.7	890±260
Las Vegas Water District Well 28	10	23	2.7±2.6	<3.5	<250
Municipal Golf Course	10	23	2.8±2.6	<3.5	<250
Tule Springs	11	23	<2.2	<3.3	<270
Tule Springs Pond	11	21	<1.9	<3.3	NA
Vegas Estates	10	23	<4.0	8.2±4.0	<250
Lida:					
Lida Livestock Company	4	27	<2.4	<3.5	NA
Pond at storage tank	4	21	<2.8	<3.5	NA
Lund:					
Gardner Grocery	12	23	<2.0	<3.3	NA
Manhattan:					
Country store	11	23	11 ±5.9	6.1±3.5	NA
Mesquite:					
Hughes Bros. Dairy	11	23	<5.7	<3.8	NA
Moapa:					
Pedersen Valley View Ranch	11	27	5.1±4.4	<3.6	NA
Mt. Charleston:					
Kyle Canyon Fire Station	11	27	<2.1	<3.3	270±270
Nyala:					
Sharp's Ranch	11	23	<2.4	<3.4	NA
Pahrump:					
Texaco Service Station	12	23	<1.9	<3.3	NA
Pioche:					
County courthouse	5	24	3.1±2.9	<3.5	NA
Round Mountain:					
Mobil Service Station	11	27	<2.2	<3.3	NA
Scotty's Junction:					
Chevron Service Station	4	23	6.2±5.4	8.6±4.0	390±240

Seefootnotes at end of table.

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Table 1. Water surveillance results, September 1973—continued

Location	Date Collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Springdale:					
Pond	13	21	<3.0	5.0±3.5	NA
Sunnyside:					
Adam McGill Reservoir	12	21	4.9±3.9	22 ±4.4	NA
Wildlife Management Headquarters	12	27	<2.1	<3.4	NA
Tonopah:					
Jerry's Chevron Station	6	23	<3.0	5.2±3.6	NA
Tonopah Test Range CP-1	5	23	<3.7	<3.5	NA
Warm Springs:					
Fallini's Pond	11	21	4.7±4.4	13 ±3.9	NA
Service Station and Cafe	12	27	18 ±8.6	25 ±4.7	NA
Twin Springs Ranch	11	23	4.1±3.9	8.0±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	12	24	<2.6	<3.6	NA
St. George:					
R. Cox Dairy	11	24	1.9±1.8	<3.5	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond; 22—Stream, river, creek; 23—Well; 24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring); 27—Spring.

[b] Two-sigma counting error provided when available. NA, not analyzed. NS, no sample.

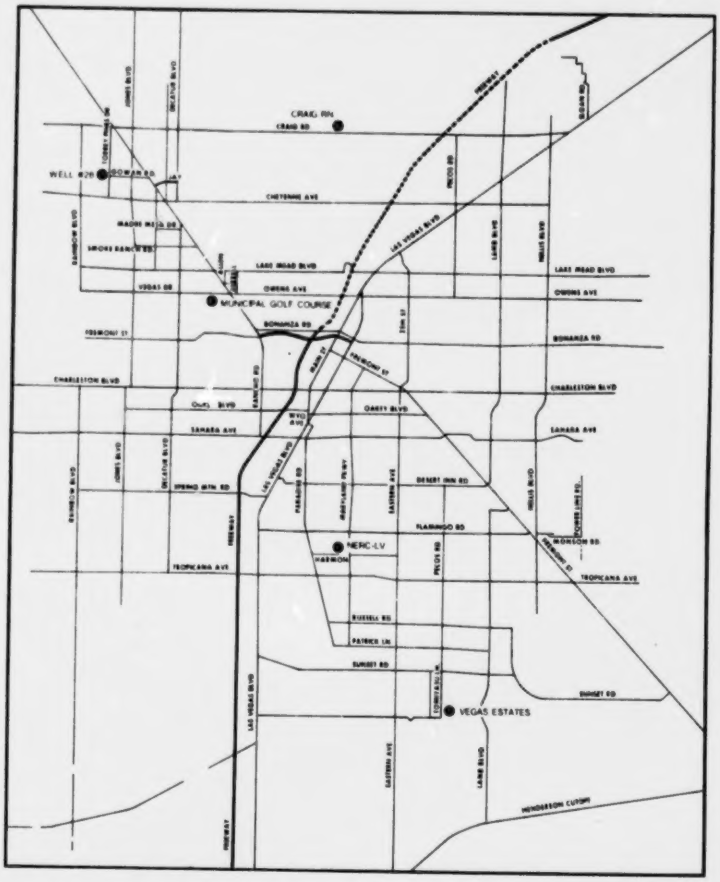

Figure 2. NERC/LV Water Surveillance Network-Las Vegas Valley

Table 2. Special analytical results for water samples collected during 1973

Location	Date collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)							
			^{89}Sr	^{90}Sr	^{226}Ra	^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
California:										
Bishop:										
Fish & Game Office	3/1	23	<2.0	<1.0	0.23 ±0.090	NA	NA	0.41 ±0.084	<0.020	0.37 ±0.076
Death Valley Junction:										
Lila's Cafe	3/1	23	<2.0	<1.0	.22 ±.10	NA	NA	8.2 ± .31	.051 ± .020	2.2 ± .16
Furnace Creek:										
Visitor's Center	3/1	27	<2.0	<1.0	.20 ±.10	NA	NA	3.0 ± .18	.029 ± .018	1.3 ± .12
Pond	3/1	21	<2.0	<1.0	.16 ±.080	<0.021	<0.017	2.6 ± .16	.024 ± .014	1.2 ± .11
Hinkley:										
Bill Nelson Dairy	3/1	23	<2.0	<1.0	.29 ±.10	NA	NA	5.4 ± .20	.13 ± .030	4.2 ± .17
Lone Pine:										
Forest Service Ranger Sta.	3/1	23	<2.0	<1.0	.16 ±.080	NA	NA	.70 ± .092	.018 ± .015	.45 ± .074
Olancha:										
Haiwee Reservoir	3/1	21	<2.0	<1.0	.19 ±.10	< .028	<.012	4.4 ± .22	.097 ± .033	3.7 ± .20
Ridgecrest:										
City Hall	3/1	23	<2.0	<1.0	.20 ±.090	NA	NA	.89 ± .099	.035 ± .019	.72 ± .087
Nevada:										
Adaven:										
Canfield Ranch	4/3	22	<1.0	<.80	.24 ±.10	NA	NA	3.5 ± .20	.049 ± .023	1.3 ± .11
Alamo:										
Williams Dairy	3/1	23	<1.0	<.90	.19 ±.10	NA	NA	8.4 ± .40	.14 ± .051	3.5 ± .26
Pahranagat Lake	3/1	21	<1.0	<.90	.92 ±.18	<.031	< .046	14 ± .42	.19 ± .049	5.2 ± .25
Sheri's Bar	3/1	23	<1.0	<.80	.17 ±.090	NA	NA	5.7 ± .32	.067 ± .035	1.5 ±.16
Ash Meadows:										
Ash Meadows Lodge	4/10	23	<2.0	<1.0	.87 ±.17	NA	NA	7.2 ± .22	.098 ± .026	2.4 ± .13
Ash Meadows Pond	4/10	21	<2.0	<1.0	.71 ±.16	<.039	< .016	25 ± .53	.30 ± .058	8.8 ± .31
Austin:										
Nevada National Bank	2/5	27	NA	NA	.32 ±.11	NA	NA	NA	NA	NA
	4/9	27	<2.0	<1.0	.40 ±.13	NA	NA	13 ± .32	.37 ± .055	12 ± .30
Blue Diamond:										
Post Office	2/9	23	<2.0	<1.0	.51 ±.14	NA	NA	4.2 ± .27	.043 ± .026	1.4 ± .15
Blue Jay Highway Maintenance Station	4/10	23	<2.0	<1.0	.27 ±.10	NA	NA	2.9 ± .16	.035 ± .019	1.1 ± .10
Cactus Springs:										
Mobil Service Station	4/11	27	<2.0	<1.0	.31 ±.12	NA	NA	1.6 ± .12	.032 ± .016	.55 ± .071
Caliente:										
Agricultural Extension Station	3/1	23	<2.0	<.90	.22 ±.10	NA	NA	13 ± .44	.14 ± .044	3.5 ± .22
Clark Station:										
Five Mile Ranch	4/10	27	<2.0	<1.0	.16 ±.090	NA	NA	.63 ± .081	.014 ± .012	.26 ± .049
Currant:										
Currant Ranch Cafe	2/7	27	<2.0	<1.0	.18 ±.10	NA	NA	14 ± .42	.20 ± .050	4.6 ± .24
	3/1	27	NA	NA	.13 ±.060	NA	NA	NA	NA	NA
Diablo:										
Highway Maintenance Station	4/11	23	<2.0	<1.0	.49 ±.14	NA	NA	1.6 ± .12	.038 ± .018	.82 ± .086
Reed Ranch	4/9	21	<2.0	4.6±1.3	.20 ±.080	<.036	< .021	19 ± .43	.092 ± .028	2.4 ± .15
Elgin:										
Water tower	2/7	23	NA	NA	.58 ±.15	NA	NA	NA	NA	NA
	3/1	23	<1.0	<.90	.67 ±.16	NA	NA	18 ± .52	.17 ± .049	4.7 ± .26
Ely:										
Chevron Service Station	2/6	24	<2.0	<1.0	.51 ±.14	NA	NA	4.3 ± .28	.050 ± .030	.99 ± .14
Comins Lake	4/16	21	<2.0	<.70	.14 ±.080	<.61	< .74	NA	NA	NA
	8/13	21	NA	NA	NA	NA	NA	12 ± .36	.24 ± .05[illegible]	4.3 ± .21
Eureka:										
Highways Maintenance Station	4/2	24	<1.0	<.80	.27 ±.11	NA	NA	2.1 ± .12	.029 ± .014	.72 ± .073
Goldfield:										
Chevron Service Station	4/9	23	<2.0	<1.0	.35 ±.12	NA	NA	.50 ± .067	<.0040	.14 ± .035
Hiko:										
Crystal Springs	3/1	27	<1.0	<.80	.64 ±.16	<.018	< .016	5.7 ± .26	.043 ± .021	1.9 ± .15
Schofield Dairy	2/5	23	NA	NA	.38 ±.12	NA	NA	NA	NA	NA
	3/1	23	<2.0	<1.0	.55 ±.14	NA	NA	22 ± .41	.34 ± .050	8.2 ± .25
	4/10	23	NA	NA	.33 ±.10	NA	NA	NA	NA	NA

See footnotes at end of table.

Table 2. Special analytical results for water samples collected during 1973—continued

Location	Date collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)							
			^{89}Sr	^{90}Sr	^{226}Ra	^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
Las Vegas:										
Desert Game Range	2/9	23	<2.0	<1.0	.27 ± .11	NA	NA	14 ± .55	.073 ± .039	2.4 ± .23
Lab II-NERC	2/12	24	<2.0	<1.0	.29 ± .10	NA	NA	9.0 ± .40	.17 ± .053	4.7 ± .29
Lake Mead Vegas Wash	2/12	21	<2.0	3.1 ± 1.2	.28 ± .11	<.018	< .020	7.1 ± .40	.17 ± .061	4.5 ± .32
Tule Springs	2/9	23	<2.0	<1.0	.22 ± .10	NA	NA	6.2 ± .40	.058 ± .039	1.7 ± .21
Tule Springs Pond	2/9	21	<2.0	<1.1	.34 ± .11	<.020	.063 ± .034	7.1 ± .38	.080 ± .040	2.2 ± .21
Craig Rch Golf Course	3/1	23	<1.0	<.80	.35 ± .12	NA	NA	3.4 ± .24	.083 ± .039	1.8 ± .17
Municipal Golf Course	3/1	23	<1.0	<.80	.59 ± .14	<.016	<.017	<.020	<.010	<.010
Vegas Estates	3/1	23	<2.0	<.90	.18 ± .090	NA	NA	6.3 ± .34	.078 ± .037	1.6 ± .17
Las Vegas Water District Well 28	3/1	23	<2.0	<.90	.22 ± .10	NA	NA	4.4 ± .29	.051 ± .032	1.2 ± .15
Lida:										
Lida Livestock Company	2/5	27	<2.0	<.90	.31 ± .10	NA	NA	6.1 ± .32	.058 ± .030	1.6 ± .16
Pond at storage tank	2/5	21	<2.0	<1.0	.28 ± .10	<.024	.028 ± .018	6.1 ± .35	.092 ± .043	1.6 ± .17
Lund:										
Gardner Grocery	2/8	23	<2.0	<1.0	.25 ± .10	NA	NA	4.1 ± .24	.076 ± .031	1.8 ± .16
Manhattan:										
Country store	2/6	23	<2.0	<1.0	.31 ± .10	NA	NA	29 ± .71	.42 ± .086	11 ± .44
	3/1	23	NA	NA	.18 ± .070	NA	NA	NA	NA	NA
Mesquite:										
Hughes Bros. Dairy	4/10	23	<2.0	<1.0	.47 ± .13	NA	NA	3.6 ± .18	.12 ± .032	2.3 ± .15
Moapa:										
Pedersen Valley View Ranch	4/10	27	<2.0	<1.0	.41 ± .13	NA	NA	.97 ± .097	.019 ± .014	.55 ± .059
Mt. Charleston:										
Kyle Canyon Fire Station	2/9	27	<2.0	<1.0	.32 ± .11	NA	NA	1.7 ± .18	.042 ± .028	.89 ± .13
Nyala:										
Sharp's Ranch	4/11	23	<2.0	<1.0	.23 ± .10	NA	NA	1.5 ± .11	.034 ± .017	.55 ± .069
Pahrump:										
Texaco Service Station	4/11	23	<2.0	<1.0	.47 ± .13	NA	NA	1.4 ± .12	.019 ± .010	.26 ± .036
Pioche:										
County Courthouse	3/1	24	<2.0	<1.0	.21 ± .10	NA	NA	2.8 ± .15	.044 ± .019	.84 ± .082
Round Mountain:										
Mobil Service Station	2/6	27	<2.0	<1.0	.28 ± .10	NA	NA	2.5 ± .20	.082 ± .036	2.0 ± .10
Scotty's Junction:										
Chevron Service Station	2/5	23	<2.0	<1.5	.71 ± .49	NA	NA	11 ± .47	.20 ± .065	4.1 ± .29
Springdale:										
Pond	4/10	21	<2.0	<1.0	.22 ± .10	<.016	<.018	4.3 ± .21	.027 ± .017	.95 ± .095
Sunnyside:										
Wildlife Management Headquarters	2/8	27	<1.0	<1.0	.25 ± .11	NA	NA	4.8 ± .30	.032 ± .024	.91 ± .13
Adam McGill Reservoir	4/17	21	<2.0	<.70	1.6 ± .24	NA	NA	3.5 ± .19	.041 ± .020	.80 ± .091
Tonopah:										
Jerry's Chevron Station	2/7	23	<2.0	<1.5	.65 ± .23	NA	NA	6.5 ± .33	.096 ± .040	3.0 ± .22
Tonopah Test Range CP-1	2/7	23	<3.0	<1.7	.22 ± .10	NA	NA	6.8 ± .33	.16 ± .050	3.8 ± .24
Warm Springs:										
Service Station and Cafe	2/5	27	<2.0	<1.3	8.5 ± .53	NA	NA	1.0 ± .13	<.010	.40 ± .080
Twin Springs Ranch	2/7	23	<3.0	<1.5	<.10	NA	NA	15 ± .19	.18 ± .048	5.4 ± .22
Fallini's Pond	3/1	21	<2.0	<1.0	NA	NA	NA	NA	NA	NA
	4/11	21	<2.0	<1.1	.29 ± .11	<.031	.047	24 ± .48	.33 ± .058	9.4 ± .30
Utah:										
Cedar City:										
M. D. Baldwin Residence	4/11	24	<2.0	<1.0	.79 ± .17	NA	NA	4.7 ± .22	.052 ± .024	1.5 ± .12
St. George:										
R. Cox Dairy	4/11	24	<2.0	<1.0	.16 ± .090	NA	NA	3.6 ± .20	.11 ± .036	2.4 ± .16

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply-mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.

the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The routine analytical results of all water samples collected in September 1973 by the NERC-LV water surveillance network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the September 1973 samples. Table 2 shows the results of water samples selected for special analyses during 1973.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California Air Sampling Program.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican Air Monitoring Program	January–June 1973	December 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1971	September 1973

1. Radiation Alert Network
September 1973

Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All field estimate results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during September 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in fuutre articles.

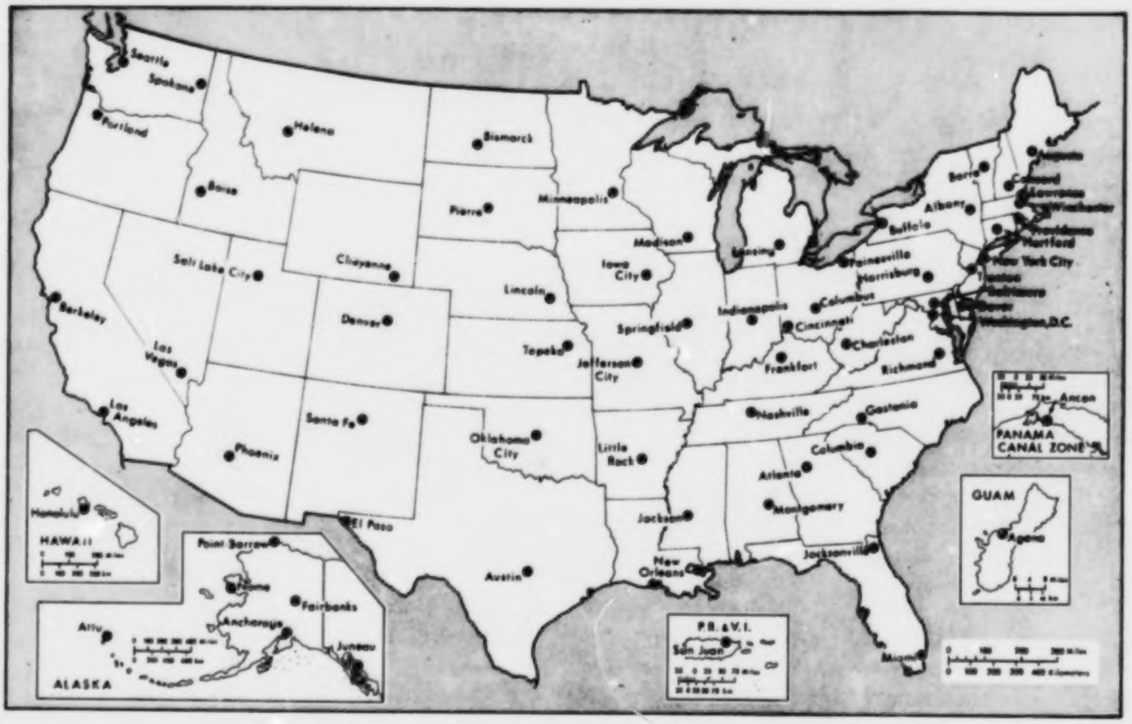

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average*	Maximum	Minimum	Average*	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	3	0	1	0.06	0.01	0.02	87	0.10
Alaska:	Anchorage	3	0	0	0	.02	<.01	.01		
Calif:	Berkeley	7	1	0	0	.03	<.01	.01	15	.04
	Los Angeles	8	1	0	0	.04	.01	.02		
Colo:	Denver	8	3	1	2	.04	.02	.03	83	.96
Del:	Dover	6	0	0	0	.03	.01	.02		
Ind:	Indianapolis	15	2	0	1	.06	<.01	.03		
Nev:	Las Vegas	12	2	0	1	.05	.02	.03		
N.Y:	Buffalo	8	1	0	0	.05	.02	.03		
N. Dak:	Bismarck	8	2	0	1	.03	.01	.02	63	.18
Ohio:	Columbus	8	3	1	1	.04	.02	.03		
Okla:	Oklahoma City	4	1	0	1	.02	.01	.02		
Oreg:	Portland	18	0	0	0	.05	<.01	.02		
Pa:	Harrisburg	18	2	0	1	.03	<.01	.02		
S.C:	Columbia	8	1	0	1	.20	.02	.08	109	.26
Network summary		149	3	0	1	0.20	<0.01	0.03	71	0.31

*The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.

2. Air Surveillance Network, September 1973

National Environmental Research Center-Las Vegas[1]
Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State Health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 2 presents the average gross beta concentrations in air for each of the network

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

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stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to 2 significant figures. For averaging purposes concentration values less than the minimum detectable concentration (~0.06 pCi/m^3 for a 350 m^3 sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are indicated as follows:

As shown by table 2, the highest gross beta concentration within the network was 0.3 pCi/m^3 at Beatty, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during September.

The 72 standby stations were activated on September 28 for one week of operation to check equipment and gather background radiation data. Since this activation was near the end of the month, many of the standby stations submitted one sample for the month of September.

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	<0.1	<0.1
≥0.05 <0.15	0.1	<0.1
≥0.15	As calculated and rounded	<calculated MDC

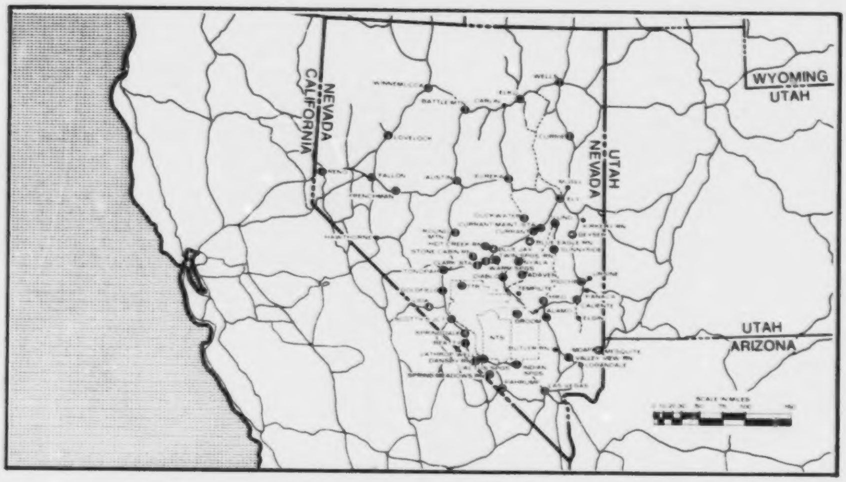

Figure 2. NERC/LV Air Surveillance Network stations in Nevada

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Table 2. Summary of gross beta radioactivity concentrations in air, September 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	<0.1	<0.1	0.1
	Phoenix	1	.1	.1	.1
	Seligman	30	.1	<.1	.1
	Winslow	1	<.1	<.1	<.1
Ark:	Little Rock	1	<.1	<.1	<.1
Calif:	Baker	25	.1	<.1	.1
	Barstow	29	.1	<.1	.1
	Bishop	30	.1	<.1	.1
	Death Valley Junction	20	.1	<.1	.1
	Furnace Creek	29	.1	<.1	.1
	Indio	1	.1	.1	.1
	Lone Pine	24	<.1	<.1	.1
	Needles	18	.1	<.1	.1
	Ridgecrest	29	<.1	<.1	.1
	Shoshone	30	<.1	<.1	.1
Colo:	Denver	1	<.1	<.1	<.1
	Durango	1	<.1	<.1	<.1
Idaho:	Boise	1	<.1	<.1	<.1
	Idaho Falls	1	<.1	<.1	<.1
	Preston	1	.1	.1	.1
	Twin Falls	1	<.1	<.1	<.1
Iowa:	Iowa City	1	<.1	<.1	<.1
	Sioux City	1	<.1	<.1	<.1
Kans:	Dodge City	1	<.1	<.1	<.1
La:	Monroe	1	<.1	<.1	<.1
	New Orleans	1	<.1	<.1	<.1
Minn:	Minneapolis	1	<.1	<.1	<.1
Mo:	Clayton	1	<.1	<.1	<.1
	Joplin	1	<.1	<.1	.1
Nebr:	North Platte	1	<.1	<.1	<.1
Nev:	Alamo	30	.1	<.1	.1
	Austin	20	.1	<.1	.1
	Battle Mountain	1	<.1	<.1	<.1
	Beatty	30	.3	<.1	.1
	Blue Eagle Ranch (Currant)	30	<.1	<.1	.1
	Blue Jay	30	.1	<.1	.1
	Caliente	30	.1	<.1	.1
	Currant Ranch	30	<.1	<.1	.1
	Currie	1	<.1	<.1	<.1
	Diablo	29	.2	<.1	.1
	Duckwater	17	.1	<.1	.1
	Elko	1	.1	.1	.1
	Ely	25	.2	<.1	.1
	Eureka	30	<.1	<.1	.1
	Fallini's Twin Springs Ranch	29	.1	<.1	.1
	Fallon	1	.1	.1	.1
	Frenchman Station	1	<.1	<.1	<.1
	Geyser Ranch	27	.1	<.1	.1
	Goldfield	29	<.1	<.1	.1
	Groom Lake	18	.1	<.1	.1
	Hiko	30	.1	<.1	.1
	Indian Springs	30	<.1	<.1	.1
	Las Vegas	18	.1	<.1	.1
	Lathrop Wells	30	<.1	<.1	.1
	Lida	30	<.1	<.1	.1
	Lovelock	1	<.1	<.1	<.1
	Lund	28	.1	<.1	.1
	Mesquite	30	<.1	<.1	.1
Nev:	Nyala	30	<.1	<.1	.1
	Pahrump	30	<.1	<.1	.1
	Pioche	28	.1	<.1	.1
	Reno	1	.1	.1	.1
	Round Mountain	28	.2	<.1	.1
	Scotty's Junction	29	<.2	<.1	.1
	Stone Cabin Ranch	30	<.1	<.1	.1
	Sunnyside	30	.1	<.1	.1
	Tonopah	30	.1	<.1	.1
	Tonopah Test Range	19	.1	<.1	.1
	Warm Springs	28	.1	<.1	.1
	Warm Springs Ranch	30	.1	<.1	.1
	Winnemucca	1	.1	.1	.1
Okla:	Muskogee	1	<.1	<.1	<.1
Oreg:	Burns	1	<.1	<.1	<.1
	Medford	1	<.1	<.1	<.1
S. Dak:	Aberdeen	1	<.1	<.1	<.1
	Rapid City	1	.1	.1	.1
Tex:	Abilene	1	<.1	<.1	<.1
	Amarillo	1	.1	.1	.1
	Austin	2	<.1	<.1	<.1
	Fort Worth	1	<.1	<.1	<.1
Utah:	Bryce Canyon	3	.1	<.1	.1
	Cedar City	25	.2	<.1	.1
	Delta	30	<.2	<.1	.1
	Dugway	1	<.1	<.1	<.1
	Enterprise	1	<.1	<.1	<.1
	Garrison	30	<.1	<.1	.1
	Logan	1	<.1	<.1	<.1

Table 2. Summary of gross beta radioactivity concentrations in air, September 1973 —continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Utah:	Milford	29	.1	<.1	.1
	Monticello	1	<.1	<.1	<.1
	Parowan	1	.1	.1	.1
	Provo	1	<.1	<.1	<.1
	Salt Lake City	1	<.1	<.1	<.1
	St. George	29	.1	<.1	.1
	Vernal	1	<.1	<.1	<.1
Wash:	Seattle	1	<.1	<.1	<.1
Wyo:	Rock Springs	1	<.1	<.1	<.1
	Worland	1	<.1	<.1	<.1

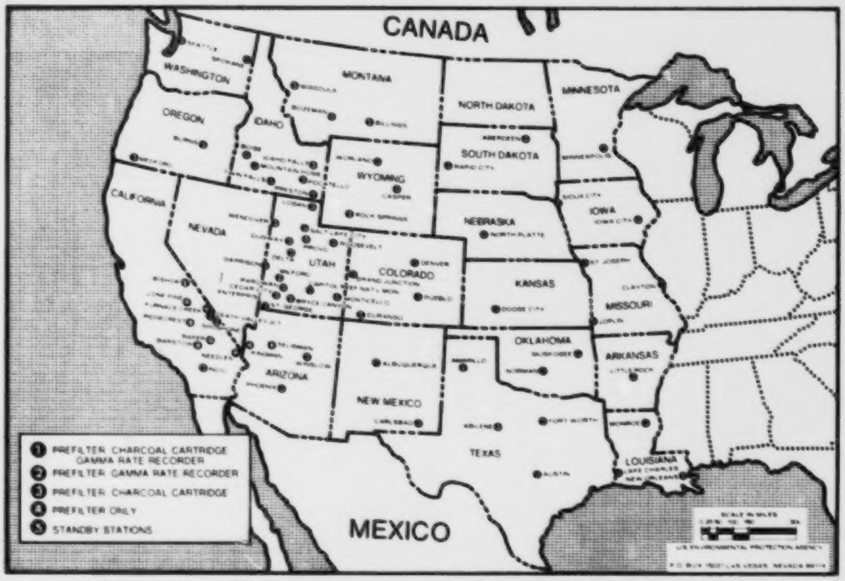

Figure 3. NERC/LV Air Surveillance Network stations outside Nevada

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

3. Canadian Air and Precipitation Monitoring Program,[3] September 1973

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for September are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, September 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.02	0.01	0.01	27	0.8
Coral Harbour	4	.01	.01	.01	6	.3
Edmonton	5	.03	.01	.01	16	.6
Ft. Churchill	4	.01	.01	.01	7	.5
Fredericton	5	.02	.01	.01	3	.3
Goose Bay	2	.01	.01	.01	6	.1
Halifax	4	.03	.01	.02	6	.1
Inuvik	2	.02	.01	.02	29	.1
Montreal	4	.03	.01	.02	9	.8
Moosonee	3	.02	.01	.02	10	.6
Ottawa	NS				9	.7
Quebec	5	.02	.01	.02	6	.7
Regina	NS				9	.5
Resolute	4	.01	.01	.01	7	.3
St. John's Nfld	1	.01	.01	.01	1	.2
Saskatoon	4	.03	.01	.02	18	.7
Sault Ste. Marie	5	.02	.01	.01	8	.4
Thunder Bay	4	.01	.01	.01	4	.6
Toronto	5	.03	.01	.02	11	.7
Vancouver	5	.01	.01	.01	9	.3
Whitehorse	5	.02	.01	.01	7	.5
Windsor	1	.01	.01	.01	7	.4
Winnipeg	5	.02	.01	.01	7	.6
Yellowknife	2	.02	.01	.02	33	.5
Network summary	84	0.03	0.01	0.01	11	0.5

NS, no sample.

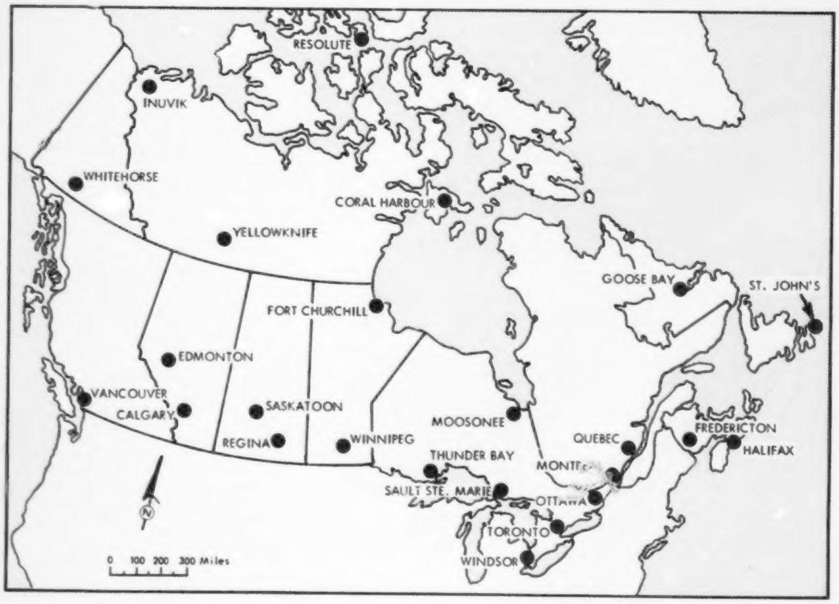

Figure 4. Canadian air and precipitation sampling stations

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

4. Pan American Air Sampling Program September 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The September 1973 air monitoring results from the participating countries are given in table 4.

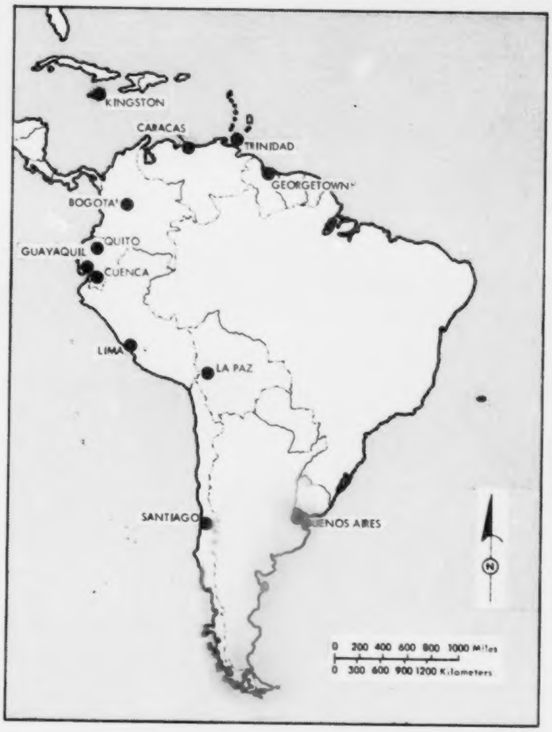

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, September 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	29	0.16	0.00	0.02
Colombia:	Bogota	20	.02	.00	.00
Ecuador:	Cuenca	16	.05	.00	.01
	Guayaquil	16	.05	.01	.02
	Quito	2	.04	.01	.03
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	7	.01	.00	.01
West Indies:	Trinidad	8	.14	.03	.06
Pan American summary		98	0.16	0.00	0.02

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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5. California Air Sampling Program September 1973

Radiologic Health Section California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 milli-

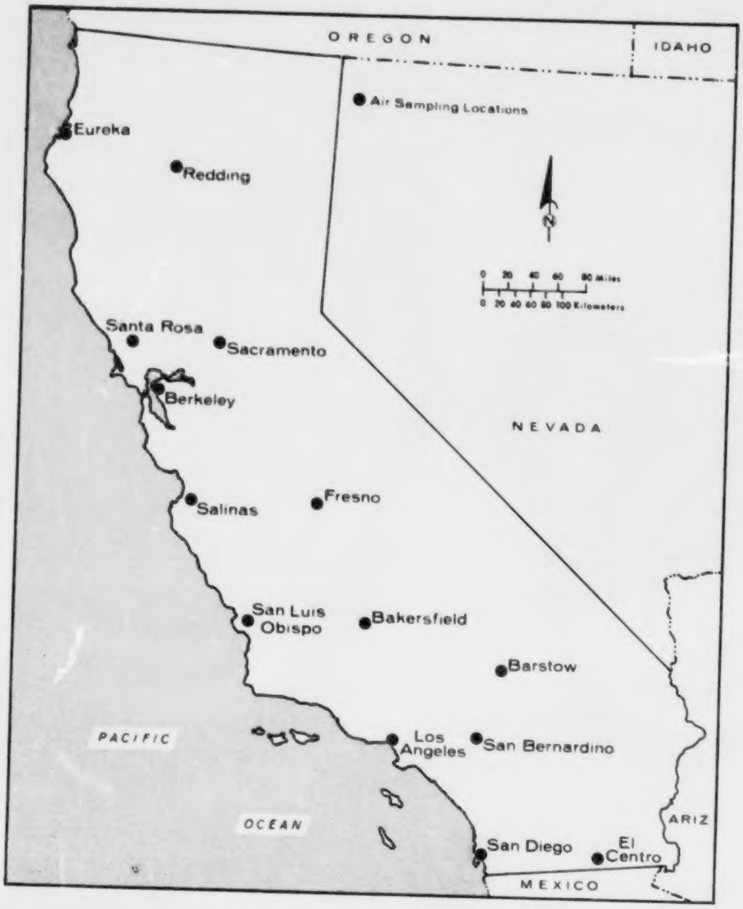

Figure 6. California air sampling program stations

meter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for September. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air September 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	0.72	0.05	0.15
Barstow	30	.44	.02	.17
Berkeley	30	.15	.00	.04
El Centro	28	.20	.03	.12
Eureka	25	.14	.00	.03
Fresno	28	1.21	.04	.24
Los Angeles	28	.17	.01	.05
Redding	27	.45	.03	.13
Sacramento	28	.42	.01	.10
Salinas	28	3.31	.00	.34
San Bernardino	28	.27	.01	.09
San Diego	28	.58	.02	.10
San Luis Obispo	28	.28	.02	.09
Santa Rosa	30	.48	.00	.07
Summary	394	3.31	0.00	0.12

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welware, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follow for the Knolls Atomic Power Laboratory-Windsor Site and the Portsmouth Area Gaseous Diffusion Plant.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory-Windsor Site[2]

(S1C Prototype Reactor Facility)

January–December 1971

General Electric Company
Windsor, Conn.

The Windsor Site of the Knolls Atomic Power Laboratory includes the S1C prototype nuclear power plant facility which is located on a 10-acre plot of government-owned property in Windsor, Conn. The facility is used primarily to train personnel in the operation of nuclear power plants. Airborne effluents are filtered and discharged through monitored stacks; liquid effluents are processed and monitored before discharge to the Farmington River.

Airborne radioactivity

Effluents from site locations where particulate airborne radioactivity could be generated are directed through ducts to discharge stacks, which are monitored for airborne radioactivity on a continuous basis. The main stack is monitored by a fixed filter sampling system; the filter is changed weekly and analyzed by radiation counting equipment calibrated to a cobalt-60 standard. The radiochemistry laboratory stack is monitored by a continuous moving filter detector, with continuous readout on a moving chart.

During 1971, the total particulate activity released from the Windsor Site was less than 54 microcuries. The volume of air discharged to the atmosphere was 1.7×10^8 m^3, giving an average value of 0.318 pCi/m^3 over the year. This is <0.1 percent of the applicable Atomic Energy Commission Concentration Guide.[3] The only gaseous radionuclide of concern, argon-41, has a half life of less than 2 hours and does not build up in the environment. It is concluded that the small quantity and low concentration of airborne activity released from the Windsor Site in 1971 had no significant effect on the environment.

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[2] Summarized from Knolls Atomic Power Laboratory, Windsor Site, Annual Environmental Radioactivity Monitoring Report, January–December 1971.

[3] AEC Manual, Chapter 0524 and Handbook, "Prevention, Control and Abatement of Air and Water Pollution."

Farmington River water samples

Liquid effluents released from the Windsor Site are collected, sampled, and processed in retention tanks prior to release to the Farmington River. Each retention tank is sampled at the start, middle, and just prior to end of discharge. The total activity discharged in the liquid waste during 1971 was <270 microcuries. This results in an average concentration of <140 pCi/liter at the point of discharge, which is <0.45 percent of the appropriate AEC standard.

Water samples were taken in the Farmington River at three locations (figure 1). These samples, which are collected quarterly, were obtained in 1 liter bottles and analyzed with a gamma spectrometer calibrated to cobalt-60 standards. The activity is reported as "gross gamma" based on the cobalt-60 calibration.

Results of the Farmington River water sampling for calendar year 1971 are shown in table 1. No indication of activity in the cobalt-60 energy range was detected. The cobalt-60 energy range minimum detectable activity values are listed for information. The average "gross gamma" activity of the Farmington River water samples was <120 pCi/liter, which is <0.4 percent of the AEC standard.

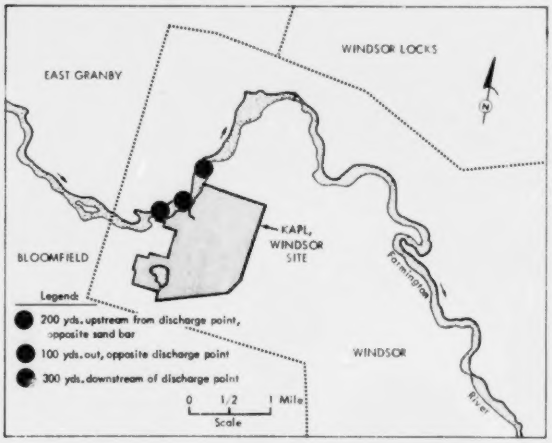
WINDSOR LOCKS
EAST GRANBY
N
KAPL, WINDSOR SITE
BLOOMFIELD
Farmington River
WINDSOR
Legend:
● 200 yds. upstream from discharge point, opposite sand bar
● 100 yds. out, opposite discharge point
● 300 yds. downstream of discharge point
0 1/2 1 Mile
Scale

Figure 1. Environmental monitoring locations, KAPL-Windsor site (S1C Prototype)

Table 1. Results of Farmington River water sample analyses, 1971

Sampling location	Number of samples	Gross gamma concentration [a] (pCi/liter)			Cobalt-60 energy range average [b] (pCi/liter)
		Maximum	Minimum	Average	
Upstream	[c] 3	190	<88	<120	<200
Opposite	[c] 3	160	<88	<110	<200
Downstream	[c] 3	<150	<88	<110	<200

[a] The minimum detectable average gross gamma concentration was 120 pCi/liter.

[b] The minimum detectable average cobalt-60 energy range gamma concentration was 200 pCi/liter.

[c] Samples not obtained during first quarter due to ice on river.

It is concluded that the small quantity and low concentration of activity in liquids released from the Windsor Site in 1971 had no significant effect on the environment.

Farmington River bottom sediment samples

Sediment samples were taken from the Farmington River bottom at three locations (figure 1). These samples were obtained by the use of a "clam shell" type dredge and represent a depth of collection of 2.5 cm. Specific gravity at standard dry weight for these samples is 1.5 g/cm^3. The quarterly sediment samples were analyzed by a gamma spectrometer calibrated with cobalt-60 standards.

The sampling locations may be described as follows:

1. Approximately 180 meters upstream from the discharge point, in the middle of the river.
2. Middle of river, opposite the discharge point.
3. Approximately 275 meters downstream from the discharge point, in the middle of the river.

The results of Farmington River sediment sampling for calendar year 1971 are shown in table 2. Cobalt-60 analyses of the river sediment samples were all less than minimum detectable activity with the exception of one sample obtained during the second quarter. A positive indication of cobalt-60 energy range activity was observed at sample location 2 during the second quarter only, when 7.3 pCi/g was measured. This concentration was less than one-third of the natural activity in the river bottom sediment (potassium-40, radium, thorium, etc.) and less than one-fourth of the AEC standard. The generally low levels of activity in the river bottom sediment and the insignificant difference between upriver and downriver samples show that Windsor Site operations are effective in protecting the environment and the public health.

Table 2. Results of Farmington River sediment sample analyses, 1971

Sampling location	Number of samples	Gross gamma concentration [a] (pCi/g wet weight)			Cobalt-60 energy range average [b] (pCi/g wet weight)
		Maximum	Minimum	Average	
Upstream	[c] 3	2.3	2.2	2.3	0.36
Opposite	[c] 3	8.7	1.6	4.2	[d] 2.7
Downstream	[c] 3	2.2	1.9	2.1	[d] .45

[a] The minimum detectable average gross gamma concentration was 0.24 pCi/g wet weight.

[b] The minimum detectable average cobalt-60 energy range gamma concentration was 0.36 pCi/g wet weight.

[c] Samples not obtained during first quarter due to ice on river.

[d] Includes effect of potassium-40 in the samples.

Perimeter fence monitoring for penetrating radiation

Beta-gamma film badges are posted on the site perimeter fence at eight locations. The film is changed and evaluated monthly according to standard techniques used for personnel monitoring film. The minimum dose measurable by the above method is 10 mrem per month. Each of the 96 perimeter films indicated a dose rate of 10 mrem/month. Therefore, the average annual dose rate was 120 mrem/year, which is the natural radiation level for this geographic location. It is concluded that Windsor Site operation did not significantly contribute to the natural background radiation of the surrounding area.

Conclusions

Results of the environmental monitoring conducted by KAPL indicates that the Windsor Site operations have met all the federal regulations pertaining to the AEC standards. All environmental samples are analyzed for cobalt-60 activity since this is the predominant and most restrictive radionuclide present in the effluents discharged.

The average gross gamma activity in the Farmington River water at the three sampling points was <120 pCi/liter (the minimum detectable concentration) and <0.4 percent of the applicable AEC standards. No positive indication of cobalt-60 activity was detected. The average gross gamma activity of the Farmington River bottom sediment samples was 2.9 pCi/g, which is <10 percent of the applicable AEC standards.

The airborne radioactivity concentration discharged to the environment during calendar year 1971 was <0.1 percent of that permitted by AEC standards. Environmental radiation monitoring with film dosimeters at the site perimeter indicated that the environmental dose rate was <120 mrem/year, which is the natural radiation level for this geographic location.

It is concluded that Windsor Site operations in calendar year 1971 did not significantly effect the local or regional environmental radiation levels.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1970	November 1972

2. Portsmouth Area Gaseous Diffusion Plant[3] January–December 1971

Goodyear Atomic Corporation
Piketon, Ohio

The Portsmouth Gaseous Diffusion Plant is owned by the U.S. Atomic Energy Commission and is operated by Goodyear Atomic Corporation, a subsidiary of the Goodyear Tire and Rubber Company. It is located in thinly populated rural Pike County, Ohio. The principal process in the plant is the separation of uranium isotopes through gaseous diffusion. Ancillary processes include feeding and removal of materials from the primary process; treatment of water for both sanitary and cooling purposes; decontamination of equipment removed from the plant for maintenance or replacement; recovery of uranium from various waste materials, such as decontamination solutions and laboratory wastes; and treatment of sewage wastes.

In the operation of a gaseous diffusion plant, as in the operation of any industrial plant, waste materials necessarily are generated as by-products of the industrial processes. Since there is an ever present possibility that the wastes may contain environmental pollutants, including radioactive materials, the effluents from the various excessive quantities of pollutants and radioactive materials are not discharged into the environment. Where necessary, treatment is provided to reduce concentrations to acceptable limits before the materials are discharged. In addition, water, air, and soil samples are collected routinely at many points both inside and outside the plant property to assure that the ambient environment has not been polluted with radioactive materials or other contaminants. The map in figure 1 shows the locations where samples normally are collected. This report describes the various environmental standards applicable to the Portsmouth Gaseous Diffusion Plant; the sampling, monitoring, and analytical procedures; and the extent of conformance with the standards.

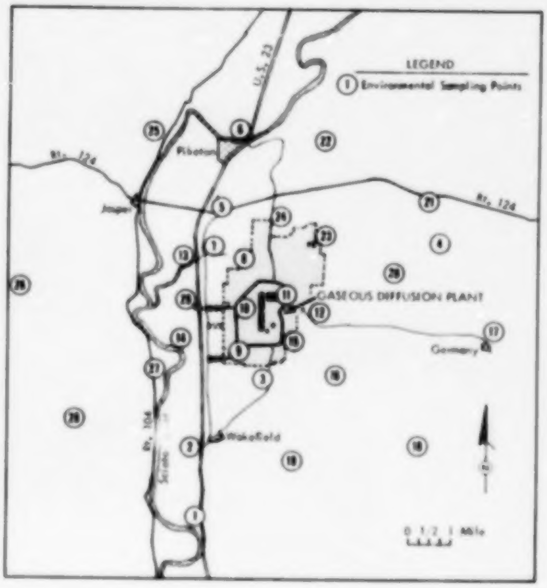

Figure 2. Sampling Locations, Portsmouth Area Gaseous Diffusion Plant

Since uranium and its daughter product, thorium-234, are the only radioactive elements present in significant quantities at the Portsmouth Gaseous Diffusion Plant, it is assumed that the measured gross alpha radioactivity is due to uranium of various enrichments and the beta-gamma radiation emanates from the thorium-234.

Air samples are collected three times each week at four locations, identified as points 3, 12, 24, and 29 on the map. Each radioactivity sample, consisting of approximately 28 cubic meters of air, is passed through a Whatman #41 filter paper at about 0.56 cubic meter per minute. The material collected on the filter paper is analyzed for gross alpha and gross beta-gamma radioactivities. Average alpha and beta-gamma radioactivity concentrations are summarized in table 3.

Two procedures are used for water sampling. One-half gallon samples are taken monthly from the Scioto River and its tributaries, Little Beaver Creek, Big Beaver Creek, and Big Run. Composite samples are collected continuously (or at specific intervals) from the three principal drainage ditches serving the plant; sampling

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[3] Data summarized from "Portsmouth Gaseous Diffusion Plant Environmental Monitoring Report—1971" (GAT-706).

Table 3. Radioactivity in air, Portsmouth Plant, January-December 1971

Location	Number of samples	Alpha radioactivity concentration (fCi/m³)		Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m³)		Average as a percent of AEC standards[a]
		Maximum	Average		Maximum	Average	
3	143	530 ±270	40 ±10	0.88	1.66 ±0.42	0.40 ±0.07	0.04
12	144	500 ±250	40 ±10	.88	2.11 ± .53	.44 ± .08	.04
24	143	530 ±270	50 ±10	1.20	2.03 ± .52	.43 ± .08	.04
29	138	480 ±240	50 ±10	1.15	1.93 ± .48	.43 ± .08	.04

[a] The AEC radiation protection standard for alpha radioactivity in air—4 pCi/m³; beta-gamma radioactivity—1 nCi/m³; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m³.

Table 4. Radioactivity in water, Portsmouth Plant, January-December 1971

Location	Number of samples	Water flow rate (m³/s)	Alpha radioactivity concentration (pCi/liter)		Average as a percent of AEC standards	Number of samples	Beta-gamma radioactivity concentration (pCi/liter)		Average as a percent of AEC standards
			Maximum	Average			Maximum	Average	
1	12	201.9	4.1 ± 2.7	2.5 ± 2.4	0.008	12	30 ± 27	12 ± 8	0.06
2	12	(b)	63.0 ±10.7	10.1 ±11.9	.03	12	76 ± 41	10 ± 14	.05
3	31	.011	4.5 ± 2.7	1.1 ± .5	.004	32	40 ± 30	9 ± 4	.04
4	11	(b)	13.5 ± 4.5	2.3 ± 3.1	.008	11	58 ± 36	14 ± 11	.07
5	12	(b)	4.5 ± 2.7	2.7 ± 2.2	.009	12	32 ± 27	9 ± 7	.04
6	41	201.9	40.5 ± 8.5	3.6 ± 2.7	.01	41	207 ± 68	10 ± 10	.05
7	15	.122	207 ±18.6	84.8 ±27.0	.28	15	1 755 ±190	806 ±367	4.03
8	15	.122	121.5 ±14.6	69.8 ±14.7	.23	15	1 634 ±200	563 ±252	2.82
10	30	.011	9.0 ± 4.1	2.5 ± .9	.008	31	90 ± 45	12 ± 7	.06
11	30	.051	333 ±23.3	136.2 ±34.8	.45	31	8 780 ±439	922 ±711	4.61
12	11	(b)	3.2 ± 2.3	1.1 ± 1.0	.004	11	27 ± 25	8 ± 5	.04
13	12	(b)	81.0 ±12.2	22.8 ±13.8	.08	12	346 ± 87	140 ± 73	.70
14	12	201.9	9.0 ± 4.1	3.5 ± 1.8	.01	12	76 ± 41	17 ± 14	.08

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis, alpha radioactivity-0.5 pCi/liter; beta radioactivity-5.0 pCi/liter.

[b] Not measured.

locations are identified on the map as points 3, 10, and 11. The composite samples are collected in 55-gallon drums. Once each week, the water in the drums is mixed thoroughly, a one-half-gallon sample is withdrawn for analysis, and the drum is drained, cleaned, and installed again in the collection system. The one-half gallon samples are analyzed for gross alpha and beta-gamma radioactivity. Radioactivity in water samples are shown in table 4.

External gamma radiation levels are measured routinely at locations 3, 12, 24, and 29 to serve as indicators of background radiation. Measurements are made three times each week with a calibrated Geiger-Muller tube at 3 feet above ground level. Average background rate for 1971 was 11.8 μR/h, which is not significantly different from the 1954 average rate, 11.9 μR/h. Background radioactivity is shown in table 5.

Table 5. Background radiation, Portsmouth Plant January-December 1971

Location	Number of samples	Exposure rate[a] (μR/h)		Exposure[b] (mR)
		Maximum	Average	
3	131	22.1 ± 3.3	11.2 ±0.4	98.1 ± 3.5
12	135	18.6 ± 2.8	10.4 ± .4	89.4 ± 3.4
24	136	78.8 ±11.8	13.5 ±1.6	119.1 ±14.1
29	130	25.7 ± 3.9	12.1 ± .5	106.0 ± 4.3

[a] Open-shield Geiger tube 3 feet above ground; limit of sensitivity—0.1 μR/h. Average background exposure rate for the Portsmouth Gaseous Diffusion Plant in 1954 was 11.9 μR/h, not significantly different from present rates.

[b] Total for the year.

The data presented in the tables show clearly that radioactivity contamination of the environment is not a problem at the Portsmouth Gaseous Diffusion Plant. Maximum concentrations of alpha radioactivity in air, beta-gamma in air, alpha in water, and beta-gamma in water during 1971 were only 13 percent, 0.2 percent, 1.1 percent, and 44 percent of the AEC standards, respectively. None of the averages were greater than 5 percent of the AEC standards. As may be seen in table 4, the only significant concentrations of radioactivity in water were found in samples taken downstream from the X-701B holding pond, which receives all the radioactive decontamination solutions from the plant. In addition, the background radiation is essentially the same as it was in 1954. Obviously, there is no widespread radioactive contamination occurring.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January-June 1971	February 1972

35

Reported Nuclear Detonations, December 1973

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion on December 14, 1973 at approximately 2:47 a.m. (EST). The signals originated at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 200 kilotons to 1 megaton.

No nuclear detonations by the United States were reported by the U.S. Atomic Energy Commission for December 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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RADIATION DATA AND REPORTS

Volume 15, Number 2, February 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

A Radioactive Isotopic Characterization of the Environment Near Wiscasset, Maine: A Preoperational Survey in the Vicinity of the Maine Yankee Atomic Power Plant[1]

Dr. C. T. Hess, Dr. C. W. Smith, H. A. Kelley, and F. C. Rock[2]

An environmental radioactivity survey was conducted in the vicinity of the Maine Yankee Atomic Power Plant prior to the operation of this facility. Measurements of environmental radioactivity were made on samples of soil, sediment, well water, surface water, estuarine water, air particulates, air moisture, and precipitation.

Natural radioisotopes in the uranium and thorium series and potassium-40 were found in most of the samples. Cesium-137 also was found in some samples.

An environmental radioactivity survey in the vicinity of the Maine Yankee Atomic Power Plant (6.4 km south southwest of Wiscasset, Maine on Bailey Point) was conducted prior to the operation of this facility. The study employed standard surveillance methods as recommended by the Bureau of Radiological Health, U.S. Public Health Service (*1*). The study was designed to isotopically characterize the radionuclear environment in a quantitative and qualitative manner, establish a meaningful and useful background baseline to which data from future radiological studies can be compared, document average values for the radiation levels from various environmental media, and locate and identify any regions of "other than average character" or contributions to the background by "manmade" radionuclides.

Measurements of the radioactivity in the environment were made on soil, sediment, well water, surface water, estuarine water, air particulate, air moisture, and precipitation in the form of snow and rain.

Study design

The basic approach used in the study design was to employ modern standard methods of measuring environmental radioactivity in typical environmental media with emphasis on measuring individual isotopes. The study was divided into two parts. Field measurements were made employing a portable multichannel analyzer system. This system, along with appropriate support equipment, was used in the field to measure various environmental media in situ (*2-5*). Laboratory measurements on collected samples were carried out at the Northeastern Radiological Health Laboratory (NERHL), Winchester, Mass. This dual approach exercised a variety of standard surveillance techniques.

The scope of this survey encompassed the three zones of environmental media, terrestrial (soil and sediment), aquatic-estuarine (well water, surface water and estuarine water) and air (air particulate, air moisture and precipitation in the form of snow and rain). Sample locations were chosen in general to be as natural and undisturbed as possible, typical of the media they represent and reproducible in the sense that measurements can be repeated in the future at the sites used in this study (*6*). The study was 8 weeks in duration beginning June

---

[1] This work was carried out under Environmental Protection Agency Contract Number 68—01—0541.

[2] Department of Physics, University of Maine, Orono, Maine 04473.

5, 1972 and ending July 28, 1972. The snow samples were taken March 11, 1972.

RADIONUCLIDES IN THE SOIL AND SEDIMENT

Soil and sediment field measurements

Radionuclides in the soil were measured at nine locations (figure 1). A sediment measurement was taken at Murphy's Corner, the location of a tidal mud flat of commercial importance to the local blood worm industry. A portable multichannel analyzer system was employed and consisted of a Northern Scientific, Inc. NS-710 multichannel analyzer powered by a Cornell-Dubilier Powercon sine wave inverter Model 12ESW25 and a 12 V.d.c., 96-amp-hour battery. The detector, a 5 cm by 5 cm NaI(Tl) crystal, was an integral crystal-photomultiplier assembly by Teledyne Isotopes, Inc., Model S-88I with 8.4 percent resolution at the cesium-137 photopeak. It was powered by a Northern Scientific, Inc., high voltage battery power pack NS-308 with the matched cable-base assembly NS-309. The detector was connected to the multichannel analyzer with 50 meters of coaxial cable (RG-59). A 45 kg lead shield, consisting of a cylinder 28 cm high and 18 cm in diameter with a 6 cm diameter concentric hole the full length of the cylinder, was used to house the detector for each field measurement. The shield was placed on the ground, the detector lowered into the shield, and a 3 cm-thick lead cap covered the upper end of the shield. The lower end of the shield was open to the soil so that the circular face of the detector was placed on the ground (a 3 cm insulating layer of plywood was used to protect the crystal from thermal shock). All field soil and sediment gamma-ray spectra were taken using this top shielded 2π geometry. It is felt that this geometry has two advantages: (1) it is reproducible, and (2) it is without bias in that it samples the soil in a nondestructive noncomponent manner. All field soil and sediment spectra were taken on half memory (512 channels) for 4000 seconds. At the end of two runs, the multichannel analyzer was returned to the Maine Yankee Environmental Studies Center at Bailey Point and the memory outputted into a model KSR-33 teletype, which provided a listing of the counts in each channel and a punched paper tape.

The information on the punched paper tapes was recorded on cards and the gamma spectra analyzed at the University of Maine Computer Center. The least squares method was used to obtain the best estimates of the amounts of each radionuclide present in each sample and an evaluation of the errors of these results. The program used was the Oak Ridge National Laboratory spectrum fitting program, Alpha-M (7). It employs the least squares method to analyze the data for which a "best fit" is mathematically computed, such that the sum of the squares of the deviations between the actual spectra, and the "best fit" is minimized. The program also uses automatic gain shift and automatic threshold shift routines to optimize the fit. The program works with a library of standard spectra from which it synthesizes the "best fit" spectra. The library used for the analysis of the soil and sediment field spectra was composed of standard spectra for potassium-40, cesium-137, the thorium-232 series, and the uranium-238 series.

Details of the calibration of this library of standards is contained in appendix A. Output from the program consists of the estimated amount of each standard spectra needed to synthesize the sample spectrum, the estimated error in the amount used for each library standard, the gain shift (if any) used to match the spectrum to the standards, the threshold or zero offset (if any) used to match the spectrum to the standards, the residuals for each channel, and a listing of suspicious channels whose residuals lie outside 2 standard deviations. In all cases, convergence was obtained in less than 20 iterations. The results of the analysis are listed in table 1.

In general, all spectra contained potassium-40. Furthermore, the spectra contained the natural decay series for thorium-232 and uranium-238. A significant amount of cesium-137, a nonnatural isotope, is contained in all spectra. The field measurements indicated no other isotopes.

Soil and sediment laboratory measurements

Soil samples were collected at Foxbird Island,

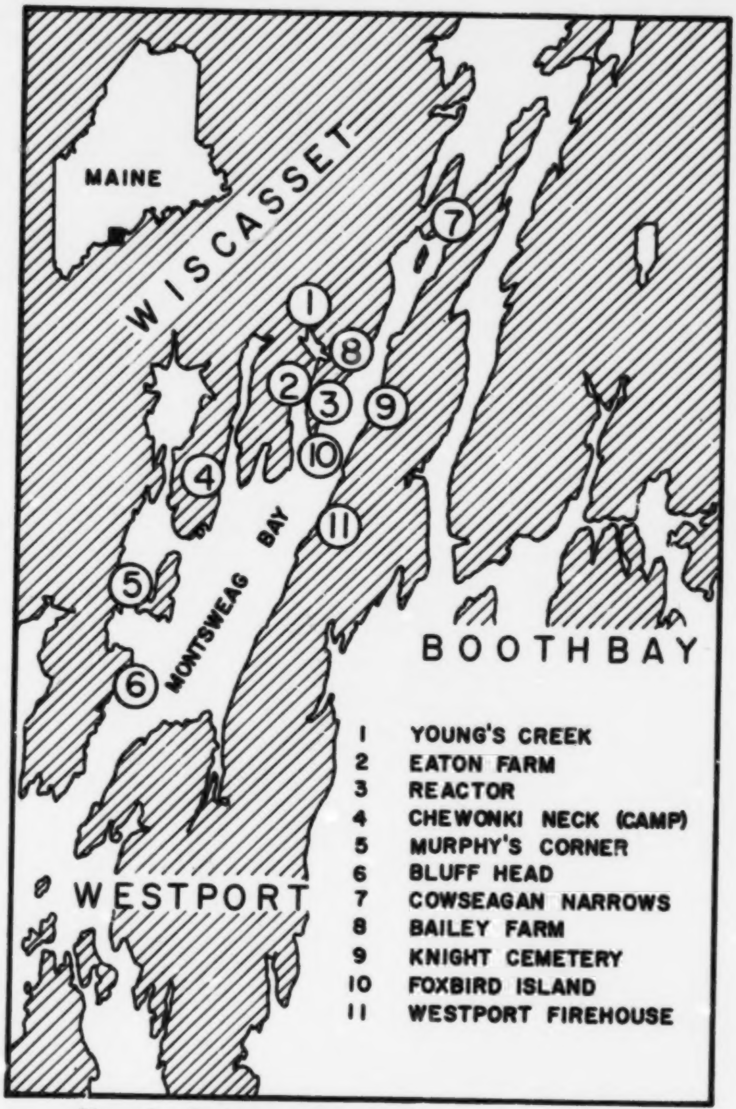

Figure 1. Region near Maine Yankee Atomic Power Plant, Wiscasset, Maine

Eaton Farm, Bailey Farm, Young's Creek, Knight Cemetery, Westport Firehouse, Chewonki Neck (camp), Cowseagan Narrows, and Bluff Head. Sediment samples were collected at Foxbird Island on the outfall side of the causeway and at Murphy's Corner. Soil samples were collected using a disc-cutter sampler which would cut a cylindrical soil sample, 15 cm in diameter by 15 cm deep. Four soil samples this size, each centered at the corner of a square grid, 25 cm on an edge, were collected at each of the nine sites. The four soil samples including surface vegetation were mixed and the root mats pulverized. The sample was then screened and all material smaller than 5 mm retained. The sample was then dried at 150°C. for 24 hours. In the case of the sediment samples, the top 2 centimeters were collected. These samples were screened and dried in an identical manner. In

Table 1. Results of soil and sediment field measurements

Location and distance from reactor site	Date measured (1972)	Type	Thorium-232 series (pCi/kg wet weight)	Uranium-238 series (pCi/kg wet weight)	Potassium-40 (pCi/kg wet weight)	Cesium-137 (pCi/kg wet weight)
Foxbird Island, 0.1 km S	6/29	soil	1 600 ±100	600 ±100	14 000 ±3 500	5 900 ± 800
Eaton Farm, 0.4 km W	6/26	soil	2 400 ±100	700 ±100	21 000 ±5 000	5 600 ±2 700
Bailey Farm, 0.8 km NE	6/27	soil	2 000 ±100	800 ±200	16 000 ±6 000	3 300 ± 600
Young's Creek, 1.0 km N	6/27	soil	1 600 ±400	600 ±200	14 000 ±9 000	4 000 ±1 400
Knight Cemetery, 1.1 km E	6/27	soil	3 100 ±300	600 ±200	20 000 ±6 000	9 500 ±1 600
Westport Firehouse, 1.8 km S	6/27	soil	1 500 ±100	500 ±100	14 000 ±3 000	7 600 ±2 000
Chewonki Neck (camp), 1.9 km SW	6/26	soil	1 900 ±100	500 ±150	20 000 ±4 000	5 000 ±1 100
Cowseagon Narrows, 3.2 km NE	6/27	soil	1 700 ±100	500 ±100	15 000 ±3 000	5 400 ± 800
Bluff Head, 4.0 km SSW	6/28	soil	2 000 ±100	800 ±300	16 000 ±5 000	6 300 ±1 400
Murphy's Corner, 2.8 km SW	7/3	sediment	1 400 ±100	400 ±200	9 000 ±4 000	7 000 ±1 900

Table 2. Results of soil and sediment laboratory measurements[a]

Location	Date collected (1972)	Date counted (1972)	Type	Thorium-232 series				Uranium-238 series			Other natural radioactivity	Man-made	Comments unidentified peaks[b] (MeV)
				^{228}Ac (pCi/kg)	^{212}Pb (pCi/kg)	^{212}Bi (pCi/kg)	^{208}Tl (pCi/kg)	^{226}Ra (pCi/kg)	^{214}Pb (pCi/kg)	^{214}Bi (pCi/kg)	^{40}K (pCi/kg)	^{137}Cs (pCi/kg)	
Foxbird Island	6/29	7/20	Soil	1 200 ±100	960 ±100	<50	950 ±230	1 600 ±800	780 ±290	700 ±90	14 000 ±1 000	940 ±85	0.077 1.234
Eaton Farm	6/12	7/17	Soil	340 ±120	1 300 ±60	400 ±400	680 ±170	2 400 ±50	1 000 ±80	630 ±70	14 900 ±400	870 ±45	.077, .210 .794
Bailey Farm	6/12	7/12	Soil	1 240 ±300	1 430 ±130	<50	1 200 ±100	<20	780 ±150	810 ±150	14 600 ±1 300	1 670 ±110	.015, 1.077 .090
Young's Creek	6/12	7/14	Tidal marsh soil	880 ±250	<20	900 ±800	1 040 ±320	3 480 ±1 110	1 210 ±120	1 075 ±120	18 200 ±400	800 ±80	.077, .090
Knight Cemetery	6/12	6/26	Soil	1 210 ±200	1 360 ±150	<50	2 150 ±550	<20	970 ±270	700 ±80	11 200 ±1 200	960 ±110	.077, .088
Westport Firehouse	6/12	6/21	Soil	1 000 ±350	900 ±100	1 300 ±700	2 000 ±340	<20	840 ±140	920 ±120	11 800 ±900	1 110 ±85	.077
Chewonki Neck (camp)	6/12	7/20	Soil	1 100 ±250	780 ±130	<50	1 660 ±500	<20	825 ±250	1 370 ±300	13 200 ±1 200	3 340 ±130	.077, .088
Cowseagan Narrows	6/13	7/24	Soil	300 ±300	1 050 ±140	<50	3 000 ±200	<20	1 140 ±200	730 ±180	13 400 ±1 250	2 620 ±130	.077, .089 1.047
Bluff Head	6/12	6/22	Soil	660 ±300	1 070 ±140	<50	2 080 ±500	<20	1 150 ±200	1 100 ±180	11 300 ±1 240	2 030 ±110	.077, .087
Foxbird Island	6/29	7/28	Tidal marsh sediment	250 ±130	1 000 ±500	1 300 ±370	780 ±320	3 190 ±540	600 ±100	500 ±180	15 000 ±350	350 ±32	.077, .089 .094
Murphy's Corner	7/3	7/27	Tidal flat sediment	1 660 ±280	950 ±120	700 ±700	70 ±150	5 390 ±900	710 ±110	740 ±120	15 200 ±1 200	450 ±80	.077, .135 .192

[a] All measurements are based on dry weight.

[b] The unidentified peaks (0.077, 0.088, and 0.098 ± 0.002 MeV) are probably due to K-shell x rays from the lead shield and from the uranium and thorium series.

each case, a dry kilogram of the sample material was shipped to NERHL for gamma-ray analysis using a Ge(Li) detector and online computer analyzer. The detector system was calibrated using sodium-22, potassium-40, manganese-54, and selenium-75. Analysis was carried out by hand using the Compton continuum subtraction method (*8*). All samples were counted for a nominal 900 minutes (with a nominal 10 percent dead time) on a 2048 channel analyzer. The results of the analysis are listed in table 2.

The minimum detectable levels for actinium-228, lead-212, bismuth-212, thallium-208, radium-226, lead-214, bismuth-214, potassium-40, and cesium-137 are 45, 20, 50, 25, 20, 10, 10, 25, and 20 pCi/kg (dry weight), respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for nominal environmental activities.

In general, all spectra contained potassium-40, contributions from both the thorium-232 series, and the uranium-238 series, and cesium-137. Furthermore, samples low in bismuth-212 are also low in radium-226. No members from the naturally occurring actinium series or neptunium series were observed.

Discussion of the soil and sediment results

Very good qualitative agreement between the soil and sediment field measurements can be seen by comparing table 1 and table 2. One would further expect that the results of the field measurements and the laboratory measurements for potassium-40 and for cesium-137, respectively, would be in an order of magnitude agreement. This is also clear from these tables. However, because the field measurements and the laboratory measurements are quite different (instrumentation, calibration, and sample character) one would not expect exact numerical agreement. Still we can see that for relative rank by activity, both measurements indicate Eaton Farm and Bailey Farm to be higher in potassium-40 with Westport Firehouse being significantly lower, and both measurements indicate Knight Cemetery and Bluff Head to be higher in cesium-137 with Eaton Farm and Young's Creek lower. Because of the quite different calibration procedures used in these two measurements (see appendix A) one cannot directly compare the activities in the two naturally occurring decay series. Nevertheless, in the case of relative rank by activity, both measurements indicate (using actinium-228 as the indicator) higher activity at the Knight Cemetery and Bailey Farm sites for the thorium-232 series, with a significantly lower activity at Young's Creek. In the case of the uranium-238 series (using radium-226 as the indicator), the Eaton Farm and Bluff Head sites are significantly higher than Murphy's Corner. Considering the layering nature of the field samples and the homogeneous nature of the laboratory samples, one cannot expect a much higher correlation than observed.

Soil and sediment classification and analysis can be found in appendix B. Classification was carried out in the field by a soil specialist from the Plants and Soils Department of the University of Maine. The same department did the laboratory analyses for pH and the exchangeable components of phosphorus, potassium, calcium, and magnesium (acetic acid extraction method). Based on soil chemistry, the measurements verify the expectation that there is a fairly consistent relationship exists between the exchangeable component of potassium in the soil and the potassium-40 activity, the magnesium in the soil and the radium-226 activity, and the phosphorus in the soil and the bismuth-214 activity. Good agreement also exists between the potassium in the soil and the soil type and the cesium in the soil and the depth of the organic mat (layers 0_1 and 0_2, see appendix B). From this, one concludes that the soil chemistry is a main feature in determining the retention capabilities in these soils for the isotopes mentioned and that the organic layers may play a dominant role in the uptake and retention of cesium.

RADIONUCLIDES IN THE WATER

Water field measurements

Radionuclides in the water were measured at Foxbird Island, Young's Creek, Cowseagan Narrows, and Bluff Head (figure 1). The portable multichannel analyzer system and support equipment used for the soil field measurements was used for these water measurements. The only modification necessary was to float the shield-detector assembly in a canoe over the water being measured. At all times, a minimum depth of 1 meter was maintained below the detector during measurement. All water field measurements were taken on half memory (512 channels) for 4 000 seconds. At the end of two runs, the multichannel analyzer was returned to the Maine Yankee Environmental Studies Center at Bailey Point and the memory outputted into the teletype. The water field measurements were only qualitatively analyzed because for reasonable in-the-field counting times (on the order of an hour), the count rate was so low that the gamma-ray photopeaks for nominal environmental concentrations were substantially masked by the counting statistics. However, several general observations can be drawn from the field data. The major contributors to the spectra were potassium-40 and the daughters of radon-222. The potassium concentration is the same for Foxbird Island, Cowseagan Narrows, and Bluff Head and is indicative of the common salinity of these estuarine samples (it corresponds to about 10 dps/liter). The potassium-40 contribution to the Young's Creek spectrum is essentially zero, as expected. The bulk of the rest of the spectra is made up of the daughters of radon-222 with the exception of the Bluff Head sample, which contained very little radioactivity. In general, the water samples were a full order of magnitude less active than the soil field measurements.

Water laboratory measurements

Water samples for laboratory analysis were collected at seven sites (tables 3 and 4). Each water sample was separated into a dissolved component and an undissolved component. This separation was done by filtering the sample in the field at the time of collection. The water was filtered using a Millipore high pressure filtering unit (a nominal over pressure of dry nitrogen gas of 28 000 kg/m^2 (40 pounds per square inch) resulted in a filter time of about 5 minutes). A Millipore 90 mm filter holder was loaded with a Whatman No. 1 paper filter, a Millipore AP3207500 spacer, a Millipore SCWP09025 cellulose ester 8.0 μm filter, a Millipore AP3207500 spacer and a Millipore HAWPO9025 cellulose ester 0.45 μm filter for each water sample. Using the above arrangement, 4 liters of water from each site were filtered. The filtered water (dissolved component) was placed in a 1-gallon plastic shipping container to which 40 ml of nitric acid were added to stabilize the sample. Prior to acidification, a 50 ml sample from each site was placed in a plastic bottle for tritium analysis. The dissolved component (1 gallon sample) and the undissolved component (filter) were sent to NERHL for gamma-ray analysis.

The dissolved component was gamma analyzed using a 12.5 cm by 12.5 cm NaI(Tl) de-

Table 3. Laboratory gamma analysis of the dissolved component of water samples[a]

Location and distance from reactor site	Type	Date collected (1972)	Date counted (1972)	Potassium[b] (g/liter ±2σ)	Cesium-137 (pCi/liter ±2σ)	Radon-222 (pCi/liter ±2σ)
Foxbird Island 0.1 km S	Estuarine	6/13	6/22	0.18±0.06	<2.0	<4.0
Eaton Farm 0.4 km W	Well	6/13	6/22	<.10	<2.0	<4.0
Bailey Farm 0.8 km NE	Well	6/13 6/13	6/22 6/29	<.10 <.10	<2.0 <2.0	81.0±13.0 <4.0
Young's Creek 1.0 km N	Surface	6/13 6/13	6/22 6/22	<.10 <.10	<2.0 <2.0	<4.0 98.2±19.2
Chewonki Neck (camp) 1.9 km SW	Well	6/13	6/27	<.10	<2.0	<4.0
Cowseagan Narrows 3.2 km NE	Estuarine	6/13	6/22	.19± .06	<2.0	<4.0
Bluff Head, 4.0 km SSW	Estuarine	6/13	6/22	.16± .06	<2.0	<4.0

[a] All samples were counted for 50 minutes in a 3.5 liter Marinelli beaker geometry.
[b] Determined by measuring potassium-40.

Table 4. Laboratory analysis of the undissolved components of water samples

Location and distance from reactor site	Date collected (1972)	Date counted (1972)	Type of sample	Sample mass (grams)	Thorium-232 series			Uranium-238 series		Other natural radioactivity	Comments
					^{228}Ac (pCi/liter)	^{212}Bi (pCi/liter)	^{208}Tl (pCi/liter)	^{214}Pb (pCi/liter)	^{214}Bi (pCi/liter)	^{40}K (pCi/liter)	Unidentified peaks[a] (MeV)
Foxbird Island 0.1 km S	6/13	7/31	Estuarine	0.131 ±.005	<45	100±20	<25	<10	<10	<25	0.077
Eaton Farm 0.4 km W	6/13	8/11	Well	.00 ±.005	<45	<10	<25	30 ±20	<10	<25	.077 .087
Bailey Farm 0.8 km NE	6/13	8/9	Well	.007 ±.005	200 ±45	<10	<25	<10	<10	<25	.077,.090
Young's Creek 1.0 km N	6/13	8/10	Surface	.045 ±.005	<45	<10	<25	<10	<10	<25	.098 .077
Chewonki Neck (camp) 1.9 km SW	6/13	8/3	Well	.002 ±.005	<45	<10	<25	<10	<10	<25	.077
Cowseagan Narrows 3.2 km NE	6/13	8/2	Estuarine	.114 ±.005	<45	<10	30 ±25	<10	<10	<25	.077
Bluff Head 4.0 km SSW	6/13	8/7	Estuarine	.163 ±.005	<45	<10	70 ±25	<10	<10	<25	.077

[a] The unidentified peaks (0.077, 0.088, and 0.098 ± 0.002 MeV) are probably due to K shell x rays from the lead shell and from the uranium and thorium series.

two groups (Bailey Farm and Eaton Farm on 6/30/72 and Chewonki Neck (camp) and Westport Firehouse on 7/3/72) separated by 72 hours and an intervening cold-front rain shower, the data are essentially identical. The exhalation rate of radon from the soils in this region is not documented, the attachment of decay products on natural aerosols is a function of the natural aerosol size distribution and therefore, this size distribution was not measured, and the filter efficiency of the fiberglass filters as a function of the aerosol size distribution is not known.

Air particulate laboratory measurements

Air particulates for laboratory analysis of radionuclides were collected at three sites (Eaton Farm, Bailey Farm, and Westport Firehouse). A Millipore pump type-xx600000 was used to pull air through a 47 mm diameter Millipore absolute aerosol 0.8 μm filter, type AAWP04700. The throughput of this system was metered for all runs with a calibrated gas volume flow meter, American Meter Company Model 10-300-PR1264. This meter was capable of reading up to 99 999.9 liters. The meter, pump, and filter holder were housed in an instrument box with a rubber hose from the filter holder to the outside. A nominal sampling time was 50 hours with a nominal sampling volume being on the order of 100 000 liters. The filters were weighed before and after collection. They were packaged carefully in separate plastic boxes and sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. for gamma-ray analysis. Each sample was prepared for analysis by digestion of the filter and contents in hydrofluoric acid. Water was then added to make the total volume of the prepared sample 200 milliliters. The samples were counted using the same Ge(Li) detector system used for the laboratory soil and sediment measurements, and using a 200 milliliter geometry. The amount of particulate collected on each filter was nominally a few milligrams. The Eaton Farm filter was counted for 3840 minutes, and the Bailey Farm and Westport Firehouse filters were counted for 900 minutes each. Full spectral analysis of all three samples indicated no peaks statistically above background levels. Background peaks were observed at 0.077 MeV, 0.094 MeV, 0.351 MeV (lead-214), 0.510 MeV (thallium-208), 0.608 MeV (bismuth-214), 0.910 MeV (actinium-228), and 1.459 MeV (potassium-40). This would indicate that the activities for these isotopes (for 100 000 liters of air) are below their respective minimum detectable levels (15 pCi for lead-214, 85 pCi for thallium-208, 15 pCi for bismuth-214, 100 pCi for actinium-228, and 100 pCi for potassium-40).

Discussion of the air particulate results

For the standard measurements employed in this section and for the nominal count times and collection techniques, the bulk of the activity is attributed to the daughters of radon-222. Careful analysis of the gamma-ray peaks for lead-212 (0.239 MeV and 0.300 MeV) and lead-214 (0.295 MeV, 0.242 MeV and 0.352 MeV), daughters of radon-220 and radon-222, respectively, indicates the presence of radon-220. The relative abundance of radon-220 to radon-222 shows a fairly good correlation with the ratio of the activity in the thorium-232 series to the activity in the uranium-238 series as indicated by the field measurements of soil. This ratio was larger for Westport Firehouse and significantly lower for Bailey Farm (the Westport Firehouse site showed evidence of radon-220).

The laboratory air particulate measurements were analyzed for the uranium-238 series, the thorium-232 series, cesium-137, potassium-40, zirconium-niobium-95 and manganese-54. None of these isotopes was found at levels above its respective minimum detectable amount. Apparently, for low efficiency detectors like Ge(Li) to yield statistically meaningful data for air particulate measurements, larger particulate mass must be accumulated. Using the minimum detectable levels for the laboratory soil measurements, one must scale the air particulate data by at least a factor of 10 000. This would require the filtering of 10^{9} liters of air having the relatively low particulate content found in this study in order to bring the activities of the various isotopes above their respective minimum detectable levels.

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tector and 3.5 liter Marinelli beaker geometry in a safe-type shield. The output from the multichannel analyzer was computer processed and the results of this analysis are presented in table 3.

The minimum detectable levels for potassium (potassium-40), cesium-137, and radon-222 are calculated to be 0.10 g/liter, 2.0 pCi/liter, and 4.0 pCi/liter, respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for nominal environmental activities.

The filters used for the undissolved component were weighed before use. After filtering, they were dried and reweighed to determine the amount of undissolved material that was deposited on them. The filters were sent to NERHL for gamma-ray analysis. Acid was used to dissolve the three filters from each sample, and water was added to bring the total volume to 200 milliliters. Each sample was counted for 900 minutes. The results of the gamma-ray analysis for the undissolved component are listed in table 4.

The minimum detectable levels for lead-214, thallium-208, bismuth-214, bismuth-212, potassium-40, and actinium-228 are 10, 25, 10, 10, 25, and 45 pCi/liter of water, respectively. These values are based on both the resolution of the detector and a 2σ statistical confidence level for the background of the counting system used. We can see from table 4 that for the size samples used, the activities are comparable to the minimum detectable levels. For an environment as uncontaminated as the one involved in this study and for water sources as clean, it would be advisable to filter perhaps 10 to 50 times as much water in order to get the gross activity higher. Because of the low activities involved, one can reach no specific conclusions concerning the undissolved component of the water.

Discussion of the water results

Several general observations can be made from the data in tables 3 and 4. The well water in this region contains considerable dissolved radon-222. This is due primarily to leaching from uranium oxide in the pegmatite deposits in this area. The estuarine waters contain, of course, potassium-40 in the dissolved form, however they also contain measurable amounts of thallium-208 in the undissolved form. Measurable amounts of bismuth-212 were found in the estuarine water off Foxbird Island and measurable amount of actinium-228 was found in the Bailey Farm well water. In general, the well waters have very low activity, especially that at the Eaton Farm site.

RADIONUCLIDES IN THE AIR PARTICULATES

Air particulate field measurements

Radionuclides in air particulates were measured at four sites, Eaton Farm, Bailey Farm, Westport Firehouse, and Chewonki Neck (camp). A staplex large volume air sampler was used in conjunction with a 20.5 cm ($8\frac{1}{16}$ inch) by 25.4 cm (10 inch) filter holder. Nuclear Associates, Inc. fiberglass filters number 08-780 were used. The air sampler was operated for 60 minutes at a nominal throughput of 1.56 m^3/min. Thus 93.6 m^3 of air were filtered at each site. The filter was folded three times (8 layers) and placed on the circular surface of the NaI(Tl) detector assembly used for the soil and sediment field measurements. For the air particulate measurements, eight layers of fiberglass filter followed by a 3 cm lead shield replaced the soil sample. All air particulate field data were obtained as soon after collection as possible (normally within a few minutes) on half memory (512 channels) for 4000 seconds (the first 2000 seconds on the first 512 channels and the second 2000 seconds on the second 512 channels). The multichannel analyzer was outputted on the teletype. Qualitative analysis shows that the bulk of the activity on the filters was due to the daughters of radon-222. The Westport Firehouse data show evidence of radon-220. This radon isotope from the thorium-232 series is just on the edge of being masked by statistical fluctuation. After a period of 24 hours, the activity on the filters is essentially background with a trace amount of potassium-40. Although the measurements were taken in

TRITIUM IN WATER, AIR MOISTURE, AND PRECIPITATION

Tritium in water

Tritium in water was measured in samples collected at seven locations, table 5. Each water sample was filtered as described earlier. A 50 milliliter sample from each site was sent to NERHL for tritium analysis using the direct-counting liquid scintillation method (*9, 10*). (The water samples were processed to remove impurities that cause quenching and a scintillation fluor was added.) The samples were counted in a low background chamber. The results of these measurements are presented in table 5.

Table 5. Tritium in water

Location and distance from reactor site	Date collected (1972)	Type	Measured results (nCi/liter ± 2σ)	Interpreted results [a]
Foxbird Island, 0.1 km S	6/13	Estuarine	0.39 ±0.2	zero
Eaton Farm, 0.4 km W	6/13	Well	.40 ± .2	zero
Bailey Farm, 0.8 km NE	6/13	Well	.34 ± .2	zero
Young's Creek, 1.0 km N	6/13	Surface	.14 ± .2	zero
Chewonki Neck (camp) 1.9 km SW	6/13	Well	.30 ± .2	zero
Cowseagan Narrows, 3.2 km NE	6/13	Estuarine	.09 ± .2	zero
Bluff Head, 4.0 km SSW	6/13	Estuarine	.40 ± .2	zero

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Tritium in air moisture

Tritium in air moisture was measured in samples collected at Eaton Farm, Bailey Farm, and Westport Firehouse. Air moisture samples were collected by drawing air through a plastic cylinder (8-cm diameter by 24-cm long) containing a desiccant (*11*). The desiccant used was indicator type Dryrite. The cylinder of desiccant was weighed before the air was pulled through and weighed afterward to insure the collection of between 20 and 30 milliliters of air moisture. Nominal collection time was between 2 and 4 hours depending on the relative humidity. The desiccant cylinders were sealed and sent to NERHL for tritium analysis. The water was thermally driven from the desiccant in a closed system. The samples were processed for tritium analysis in the usual way. The results of these measurements are listed in table 6.

Table 6. Tritium in air moisture

Location and distance from reactor site	Date collected (1972)	Quantity measured (ml)	Measured results (nCi/liter ±2σ)	Interpreted results (nCi/liter)[a]
Eaton Farm, 0.4 km W	6/29	33.7	0.60 ±0.2	0.6
Bailey Farm, 0.8 km NE	6/15	33.1	19.1 ± .2	19.1
Westport Firehouse, 1.8 km S	6/27	33.4	.60 ± .2	.6

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Tritium in precipitation

Tritium in precipitation was measured in snow samples collected at Knight Cemetery and Westport Firehouse on March 11, 1972 and rain samples collected at Eaton Farm and Bailey Farm on June 30, 1972. These samples were filtered in the same manner used for the water samples. Fifty milliliter samples were sent to NERHL for tritium analysis using the liquid scintillation method. The results of the analysis are listed in table 7.

Table 7. Tritium in precipitation

Location and distance from reactor site	Date collected (1972)	Type	Measured results (nCi/liter ±2σ)	Interpreted results (nCi/liter)[a]
Eaton Farm, 0.4 km W	6/30	Rain	0.40 ±0.2	zero
Bailey Farm, 0.8 km NE	6/30	Rain	1.10 ± .2	1.1
Knight Cemetery, 1.1 km E	3/11	Snow	.26 ± .2	zero
Westport Firehouse, 1.8 km S	3/11	Snow	.17 ± .2	zero

[a] The minimum detectable level for the analysis of tritium by the direct liquid scintillation counting method used in this study is 0.4 nCi/liter. All values equal to or less than 0.4 nCi/liter will be reported by convention as zero. Values greater than 0.4 nCi/liter but which round to this value will be reported as 0.4 nCi/liter.

Discussion of tritium measurements

Tritium has a half-life of 12.5 years. It is produced naturally by cosmic radiation and artificially by nuclear weapons and nuclear reactors. The nuclear weapons tests of the early fifties and subsequent tests have generated considerable amounts of tritium so that now most of the tritium found in the interchangeable environmental reservoirs is manmade tritium and will remain so for quite some time, even without further testing (*12*). The purpose of the tritium measurements was to document typical values for the tritium levels in various environmental media prior to the operation of the Maine Yankee Atomic Power Plant. The major uptake of tritium by the environment and hence the impact, if any, on the environment is via tritiated water, therefore, the HTO component of the tritium inventory was measured. No effort was made to measure the variation in the preoperational tritium background because it was not possible to make a meaningful measurement of this variation in the 8 weeks of this study. However, some tritium background measurements have been made by Maine Yankee, and over a period of a few years, these data may be analyzed for trends and variations. To our knowledge, no measurements have been made (other than in this study) of tritium in the air moisture in this region. The authors feel that this is an unfortunate oversight, and in view of the dense sea fogs characteristic of the Maine Coast under certain meteorological conditions, some effort should be made in this respect. In general, the results of the tritium measurements in this study were as expected for environmental levels and in line with those made by Maine Yankee. The only exception to this was the rather large value found in the air moisture collected at Bailey Farm on 6/15/72 (table 6). This is a fairly high value for an environmental sample and cannot be explained at this time.

Conclusions

The field and laboratory soil and sediment measurements show good qualitative agreement in ranking the various sites by relative activity for the radionuclides detected. The character of the radioactivity at the eight soil sites is quite different from that of the two sediment sites and the tidal marsh soil site (tables 1 and 2). These latter three sites (Foxbird Island tidal marsh sediment, Murphy's Corner tidal flat sediment and Young's Creek tidal marsh soil) show a relatively high amount of radium-226 and a relatively low amount of cesium-137 as compared to the other eight sites. This is in agreement with the soil chemistry of these samples as indicated by the high amount of exchangeable magnesium in the tidal sample and the relative lack of an organic top layer structure as compared to the soils. The cesium-137 activity was observed to be high at Knight Cemetery, Chewonki Neck (camp), Cowseagan Narrows and Bluff Head sites. We associate this activity with the loose organic mat (O_2) and the decayed organic mat (O_1) characteristic of these sites.

The dominant activity in the dissolved component of the water samples was dissolved radon-222 in the well water at Bailey Farm and Chewonki Neck (camp) (table 3). Potassium-40 in dissolved form was measured in estuarine water at sites, Foxbird Island, Cowseagan Narrows, and Bluff Head. Measurable amounts of activity were found in the suspended solids components of the water samples (table 4): actinium-228 was found in the Bailey Farm well water, bismuth-212 at Foxbird Island, thallium-208 was found in the Bailey Farm well water, bismuth-212 at Foxbird Island, thallium-208 at Cowseagan Narrows and Bluff Head and lead-214 in the Eaton Farm well water. Cesium-137 activity was below the minimum detectable level in both the dissolved and suspended solid measurements.

Air particulate field measurements showed radon-222 daughter activity at all sites. These data also show evidence of radon-220 daughters at the Westport Firehouse site.

Measurements of tritium in well, surface, and estuarine water samples showed no activity above the minimum detectable level (0.40 nanocuries per liter). Measurable quantities of tritium were found in air moisture (table 6). An unusually large amount was measured for the air moisture at the Bailey Farm site on June 15, 1972. A measurable amount of tritium was found in a rain sample taken at this site.

All gamma-ray spectra measured by the Ge(Li) detector system were examined for statistically significant peaks corresponding to gamma-ray energies for barium-140, iron-55, molybdenum-99, cesium-134, zirconium-95, niobium-95, cobalt-58, manganese-54, rubidium-88, iron-59, and cobalt-60. The activity of all these radionuclides was below their respective minimum detectable levels.

APPENDIX A

Calibration method for the field measurements

The field measurements in this study were computer analyzed using a least squares method. The computer program employed was developed at the Oak Ridge National Laboratory and is a gamma-ray spectrum fitting program known as ALPHA-M. This program uses a library of standard gamma-ray spectra, taken with the same detector and shield geometry as was used for the sample spectra being analyzed. For these measurements, spectra for potassium-40, cesium-137, the thorium-232 series and the uranium-238 series were used. The top shielded 2π geometry was simulated by uniformily distributing a known amount of radionuclide in an adequately large cylindrical volume of washed quartz sand. The size of this cylinder was determined experimentally using the natural abundance of potassium-40 in potassium chloride. Potassium-40 was chosen because the gamma ray from this radionuclide falls at the energy for minimum absorption for sand *(13)*. Thus, an adequately large volume (a volume for which the addition of further material does not increase the observed activity) as determined in this manner will be adequate for all other gamma-ray energies, both larger and smaller than that for potassium-40 (1.459 MeV). The volume used was 16.8 cm high by 105 cm in diameter (the mass of dry washed sand contained in this volume is 25.45 kilograms). In order to insure that the radionuclide was dispersed uniformly throughout the sand and in order to further simulate the absorption coefficient of soil, the cylinder of dry sand was saturated with 5 liters of a water solution of the radionuclide. The standard spectra were then measured using the same detector, shield, cable and multichannel analyzer that were used for the field measurements. The detector-shield assembly was placed on the cylinder of the water-saturated sand in the same manner as used for the field measurements. All spectra were corrected for background activity by using a sand-and-water-only sample.

Calculation of the activity of each standard was carried out knowing the amount of radionuclide dispersed in the cylindrical volume and its branching ratio. The potassium-40 standard was calculated based upon the natural abundance of potassium-40 in natural potassium. Potassium chloride was used as the host. The cesium-137 standard was calculated based upon the known activity of a sample of cesium-137 provided by the Analytical Quality Control Service of the Environmental Protection Agency. The thorium-232 series standard was calculated based upon a sample of thorium nitrate known to be in secular equilibrium. This sample was 25 years old or older and its spectrum was calibrated in the usual manner. The uranium-238 series standard was calculated based upon a sample of uranium ore. The spectrum of the uranium ore was calibrated in the usual manner.

This calibration method was designed to simulate the top shielded 2π geometry and to take into account the absorption of gamma rays in the soil. It does not take into account the variations in the soil due to layering. These variations are primarily variations in radionuclide composition from layer to layer, with gamma-ray absorption gradations usually being a secondary consideration.

APPENDIX B

Soil and sediment classification and analysis

The soil and sediment samples in this study were classified and analyzed in the following manner. A field study at all soil and sediment sites was conducted by a soil specialist from the Department of Plants and Soils at the University of Maine. The soils and sediments were classified according to soil series name and the layer structures were typed and measured to a depth of 1 meter or bedrock. The samples collected from these sites for the soil and sediment laboratory measurements were chemically analyzed by the Maine Soil Testing Service at the University of Maine. The acetic acid extraction method was used to measure the amount of exchangeable phosphorus, potassium, calcium, and magnesium in all samples. The pH of each sample also was measured. The results of this classification and analysis are reported in table B-1.

The layer types and depths are given for each sample in the last column of the table. The soil field samples were collected to this depth as recommended by the staff of the Northeastern Radiological Health Laboratory.

The soils at the sites, Eaton Farm, Bailey Farm and Chewonki Neck (camp) had been disturbed by plowing to a depth of approximately 15 cm. This shallow plowing (pre-mechanical plowing) took place at least 50 years ago as evidenced by the size of the trees at these locations. All other sites showed layering by natural processes only.

Table B-1. Results of soil and sediment classification analysis

Location and distance from reactor site	Sample	Soil series name	pH	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Layer types and depths in top 15 cm (*14*)
Foxbird Island, 0.1 km S	Soil	Agawan on bedrock	4.15	5	25	250	5	O_2 0–2.5 cm, O_1 2.5–10 cm A_1 10 cm–17.5 cm
Eaton Farm, 0.4 km W	Soil	Buxton (disturbed)	4.37	25	75	250	25	A_p 0–12.5 cm A_p and rocks 12.5–25 cm
Bailey Farm, 0.8 km NE	Soil	Poor Buxton	4.70	25	50	250	5	A_p 0–20 cm
Young's Creek, 1.0 km N	Tidal marsh soil	Tidal marsh	4.45	25	50	375	25	O_1 0–2.5 cm, A_1 2.5–5 cm A_1 5–7.5 cm, A_3 7.5 cm–15 cm
Knight Cemetery, 1.1 km E	Soil	Hollis	3.80	5	25	250	25	O_2 0–2.5 cm, O_1 2.5–5 cm A_0 5–7.5 cm, A_1–B_{21}
Westport Firehouse, 1.8 km S	Soil	Hollis	4.30	5	25	250	5	O_1 0–2.5 cm, A_0 2.5–5 cm A_1–B_{21}
Chewonki Neck (camp), 1.9 km SW	Soil	Hinkley	4.10	50	25	250	5	O_2 0–5 cm, A_p 2.5–5 cm B_{21} 5–15 cm
Cowseagan Narrows, 3.2 km NE	Soil	Hartland	3.90	5	25	250	5	O_2 0–5 cm, O_1 5–10 cm A_2 10–12.5 cm, B_{21} 12.5–22.5 cm
Bluff Head, 4.0 km SSW	Soil	Hollis	3.95	5	25	250	5	O_2 0–0.5 cm, O_1 0.5–3 cm A_2 3–8 cm, B_{21} 8–18 cm
Foxbird Island, 0.1 km S	Tidal marsh sediment	Marine sediment	6.10	50	500	375	1 000	0–2 cm Medium silt to medium sand
Murphy's Corner, 2.8 km SW	Tidal flat sediment	Marine sediment	5.70	50	500	500	1 500	0–2 cm Fine silt to fine sand

APPENDIX C

Discussion of error analysis used in the Compton continuum subtraction method

The Compton continuum subtraction method was used for the quantitative analysis of all laboratory measurements employing the Ge(Li) detector system. The measurements involved were soil, sediment, undissolved solids in water and air particulates, as well as the counting efficiency of the detector itself and the measurement of the background for these laboratory measurements.

For the Compton continuum subtraction method, once the photopeak was located, the most reproducible procedure is to use the peak channel and an equal number of channels on either side of that channel. We chose to use the photopeak channel and five channels on each side. A line estimating the base of the photopeak under consideration is then constructed. There are two numbers involved in the analysis: the sum of the 11 channels encompassing the photopeak, and the sum of the 11 values making up the baseline. We now associate with each of these numbers an uncertainty. The statistical analysis of random variables tells us in this case that each individual value N has associated with it a probable absolute error equal to $\sqrt{N}$. Calling the number of counts in the 11 channels of the baseline B, the area of the photopeak will be P—B. The absolute error associated with this area will be $\sqrt{P} + \sqrt{B}$ since the absolute error in an addition or subtraction is equal to the sum of the absolute errors in the input quantities. We find reported in tables 1, 2, 4, and appendix D, values with errors. These values and errors are based upon the photopeak area and associated absolute error, that is $(P-B) \pm (\sqrt{P} + \sqrt{B})$.

When the photopeak area (P—B) is less than $\sqrt{P} + \sqrt{B}$ we say that the amount of the particular isotope involved is less than the minimum detectable level. The minimum detectable level for a particular isotope is based upon the absolute error $\sqrt{P} + \sqrt{B}$, the detector efficiency calibration, and the appropriate branching ratio for that radionuclide. There are of course complicating circumstances for which this straightforward procedure would have to be modified. These more complicated cases were handled on an individual basis. The most frequent complication confronted in this study was cases in which the branching ratio was known to less accuracy than the statistical limits placed on the photopeak area. The area in these cases, dominated by the branching ratio information, was calculated based on the relative error in the product of the numbers involved as well as the statistical limitations on these numbers.

APPENDIX D

Background spectra for Ge(Li) analysis

Because of the very low activity in the undissolved water component and air particulate samples analyzed by laboratory measurement, it was necessary to qualify the background spectrum of the Ge(Li) detector shield assembly employed. For this purpose, an empty 200 milliliter container was placed in the usual manner in the Ge(Li) system and a spectrum was recorded. The count time was 3 840 minutes, beginning 8/4/72. The resulting spectrum contained seven statistically significant peaks. Peaks one and two, at 0.077 MeV and 0.087 MeV, respectively, are unidentified. The third peak, at 0.510 MeV, corresponds to 790 ± 80 pCi of thallium-228; the fourth peak, at 0.609 MeV, and the seventh peak, at 1.763 MeV, correspond to 80 ± 15 pCi of bismuth-214; the fifth peak, at 1.459 MeV, corresponds to 900 ± 100 pCi of potassium-40; and the sixth peak, at 1.592 MeV, corresponds to 300 ± 100 pCi of actinium-228. All laboratory data reported in this study have been corrected for this background.

Acknowledgements

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REFERENCES

(*1*) MAGNO, P. J., E. J. BARATTA and E. FERRI. Procedures for the Chemical and Radiochemical Analysis of Environmental Samples, NERHL-64-1. (1967).

(*2*) BECK, H. L., J. DeCAMPO, and C. GOGOLAK. *Insitu* Ge (Li) and NaI (Tl) gamma-ray spectrometry, HASL-258. U.S. Atomic Energy Commission, New York, N.Y. (1972).

(*3*) BECK, H. L. The physics of environmental gamma radiation fields. Second International Symposium on the Natural Radiation Environment, Houston Tex (1972).

(*4*) BECK, H. L. The absolute intensities of gamma rays from the decay of [illegible]U and [illegible]Th, HASL-262. U.S. Atomic Energy Commission New York N.Y. (1972).

(*5*) ADAMS, J. A. S. and W. M. LOWDER. The natural radiation environment. University Chicago Press (1964).

(*6*) ENVIRONMENTAL PROTECTION AGENCY. Environmental radioactivity surveillance guide, ORP/SID 72–2. Surveillance and Inspection Division, Office of Radiation Programs, EPA (June 1972).

(*7*) SCHONFELD, E. Alpha-A computer program for the determination of radioisotopes by least-squares resolution of the gamma-ray spectra, ORNL-3810. (July 1965).

(*8*) SHEEHY, J. P. Radionuclide analysis by gamma ray spectroscopy. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (1966).

(*9*) BRANSOME, JR., E. D. The current status of liquid scintillation counting. Greene and Stratton, New York, N.Y. (1971).

(*10*) HORROCKS, D. L. and C. T. PENG. Organic scintillators and liquid scintillation counting. Academic Press, New York, N.Y. (1971).

(*11*) COCHRAN, J. A., D. G. SMITH, P. J. MAGNO, and B. SHLEIN. An investigation of airborne radioactive effluent from an operating nuclear fuel reprocessing plant, BRH/NERHL 70–3 (July 1970) p. 26.

(*12*) JUNGE, C. E. Air chemistry and radioactivity. Academic Press, N. Y. (1963).
liquid scintillation counting. Grune and Stratton, New York (1971).

(*13*) HESS, C. T. and C. W. SMITH. Calibration method for in-situ environmental radiation measurements using top shielded 2π Geometry. Bull Amer Phys Soc Series II. 18:242 (1973).

(*14*) BUCKMAN, H. O. and N. C. BRADLEY. Nature and properties of soils, 7th Edition. MacMillian (1969).

SECTION I. MILK AND FOOD

Milk Surveillance, October 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

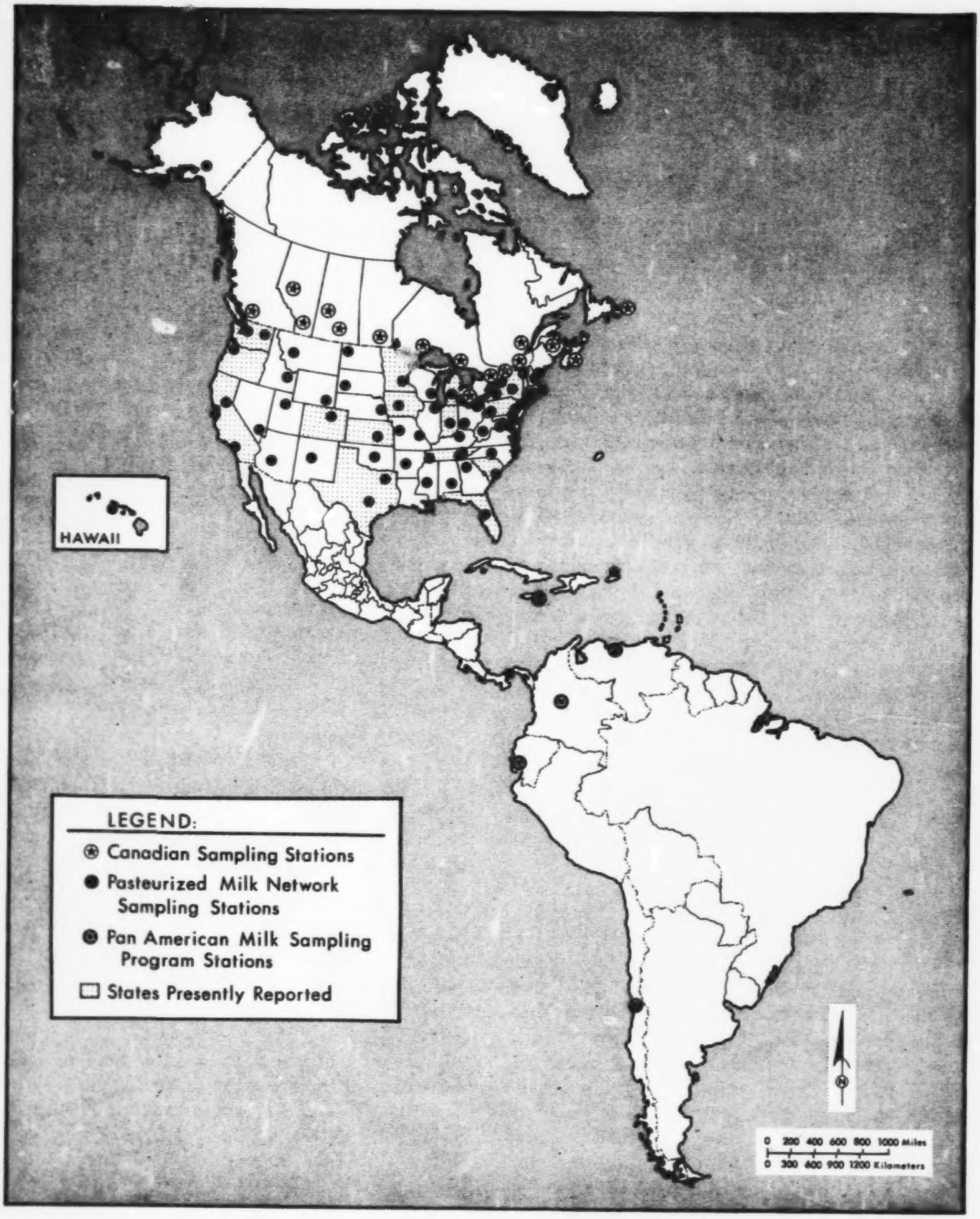
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
▨ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Research and Developments conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reported in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	4
Alaska:	Palmer [c]	P	NA	4	0	1
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	NA	10	0	1
Calif:	Los Angeles [c]	P	NA	0	0	0
	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	4	10	0	7
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	2	1	0	1
	Mendocino	P	2	2	0	3
	Sacramento	P	0	2	0	2
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	0	2
	Shasta	P	0	2	0	2
	Sonoma	P	0	2	0	3
Colo:	Denver [c]	P	NA	3	0	0
	East	R	NS	NA	NS	22
	Northeast	R	NS	NA	NS	0
	Northwest	R	NA	NA	[d] 0	2
	South Central	R	NS	NS	NS	NS
	Southeast	R	NA	NA	[d] 0	0
	Southwest	R	NS	NA	NS	2
	West	R	NA	NA	[d] 0	0
Conn:	Hartford [c]	P	NA	4	0	4
	Central	P	7	6	0	0
Del:	Wilmington [c]	P	NA	5	0	2
D.C:	Washington [c]	P	NA	3	0	1
Fla:	Tampa [c]	P	NA	4	23	28
	Central	R	9	5	25	30
	North	R	9	7	16	13
	Northeast	R	7	6	38	33
	Southeast	R	6	5	65	50
	Tampa Bay area	P	7	5	34	29
	West	R	8	8	0	8
Ga:	Atlanta [c]	P	NA	4	0	5
Hawaii:	Honolulu [c]	P	NA	1	0	0
Idaho:	Idaho Falls [c]	P	NA	3	0	0
Ill:	Chicago [c]	P	NA	6	0	2
Ind:	Indianapolis [c]	P	NA	4	0	3
	Central	P	4	6	0	7
	Northeast	P	5	6	10	9
	Northwest	P	7	7	10	8
	Southeast	P	6	6	10	6
	Southwest	P	6	7	10	9
Iowa:	Des Moines [c]	P	NA	4	0	0
	Des Moines	P	NA		NA	
	Iowa City	R	NA		NA	
	LeMars	R	NA		NA	
	Little Cedar	P	NA		NA	
Kans:	Wichita [c]	P	NA	5	0	0
	Coffeyville	P	6	7	10	7
	Dodge City	P	5	5	0	5
	Falls City, Nebr	R	NS	NS	NS	NS
	Hays	P	5	6	0	4
	Kansas City	P	4	5	10	7
	Topeka	P	8	7	0	5
	Wichita	P	6	6	0	6
Ky:	Louisville [c]	P	NA	5	11	2
La:	New Orleans [c]	P	NA	8	0	1
Maine:	Portland [c]	P	NA	5	11	17
Md:	Baltimore [c]	P	NA	6	0	3
Mass:	Boston [c]	P	NA	7	9	12
Mich:	Detroit [c]	P	NA	6	0	2
	Grand Rapids [c]	P	NA	7	0	1
	Bay City	P	NS	7	NS	0
	Charlevoix	P	9	7	0 (4)	2
	Detroit	P	12	6	0	0
	Grand Rapids	P	12	7	13	3
	Lansing	P	16	9	0	3
	Marquette	P	12 (2)	9	0 (3)	3
	Monroe	P	31	10	12	1
	South Haven	P	17	10	0 (4)	3
Minn:	Minneapolis [c]	P	NA	7	0	3
	Bemidji	P	6	7	11	18
	Duluth	P	18	16	16	18
	Fergus Falls	P	6	6	0	0
	Little Falls	P	19	18	24	28
	Mankato	P	6	5	16	0
	Marshall	P	NS	4	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:						
	Minneapolis	P	NA	9	0	0
	Rochester	P	NS	7	NS	0
Miss:	Jackson [c]	P	NA	8	11	7
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	7	0	1
Mont:	Helena [c]	P	NA	2	0	0
Nebr:	Omaha [c]	P	NA	3	0	0
Nev:	Las Vegas [c]	P	NA	4	0	0
N.H:	Manchester [c]	P	NA	8	12	8
N.J:	Trenton [c]	P	NA	5	0	3
N. Mex:	Albuquerque [c]	P	NA	0	0	0
N.Y:	Buffalo [c]	P	NA	4	0	3
	New York City [c]	P	NA	5	0	3
	Syracuse [c]	P	NA	6	0	1
	Albany	P	0 (2)	4	0 (5)	0
	Buffalo	P	5	5	22	0
	Massena	P	NA	5	0	0
	New York City	P	5	7	0	0
	Syracuse	P	NS	5	NS	0
N.C:	Charlotte [c]	P	NA	7	0	6
N. Dak:	Minot [c]	P	NA	7	0	0
Ohio:	Cincinnati [c]	P	NA	5	0	2
	Cleveland [c]	P	NA	6	0	2
Okla:	Oklahoma City [c]	P	NA	3	0	0
Oreg:	Portland [c]	P	NA	4	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	0	2
	Pittsburgh [c]	P	NA	8	0	4
	Dauphin	P	5	4	0	0
	Erie	P	7	6	0	0
	Philadelphia	P	4	4	0	1
	Pittsburgh	P	7	6	0	0
R.I:	Providence [c]	P	NA	5	0	6
S.C:	Charleston [c]	P	NA	6	13	7
	Chapin	R	NS	8	NS	11
	Clemson	R	NS	7	NS	6
	Columbia	R	NS	8	NS	10
	Fairfield	R	NS	7	NS	13
	Hartsville-02	R	NS	7	NS	14
	Hartsville-03	R	NS	16	NS	15
	Lee County	R	NS	8	NS	17
	Oconee County	R	9	8	11	8
	Pickens	R	7	7	6	6
	Wiliston	R	7	7	19	15
	Winnsboro	R	NS	7	NS	16
S. Dak:	Rapid City [c]	P	NA	5	0	1
Tenn:	Chattanooga [c]	P	NA	6	0	3
	Knoxville [c]	P	NA	0	0	0
	Memphis [c]	P	NA	6	0	2
	Chattanooga	P	NA	7	0	4
	Clinton	R	NA	6	0 (2)	5
	Fayetteville	R	NA	7	0 (3)	4
	Kingston	R	NA	7	0 (3)	0
	Knoxville	P	NA	5	0	2
	Lawrenceburg	R	NS	6	NS	6
	Nashville	P	NS	5	NS	3
	Pulaski	R	NA	6	0 (2)	0
	Sequoyah	R	NS	8	NS	0
Tex:	Austin [c]	P	NA	0	0	0
	Dallas [c]	P	NA	3	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	P	NA		NA	
Utah:	Salt Lake City [c]	P	NA	2	0	1
Vt:	Burlington [c]	P	NA	4	0	6
Va:	Norfolk [c]	P	NA	6	0	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1973 and 12-month period, November 1972 through October 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Seattle [c]	P	NA	2	0	0
	Spokane [c]	P	NA	5	0	0
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	4	3	10	3
	Sandpoint, Idaho	R	4	5	0	0
	Skagit County	R	3	4	0	1
W. Va:	Charleston [c]	P	NA	6	0	3
Wisc:	Milwaukee [c]	P	NA	4	0	2
Wyo:	Laramie [c]	P	NA	1	0	1
CANADA:						
Alberta:	Calgary	P	NA		6	9
	Edmonton	P	NA		14	13
British Columbia:	Vancouver	P	NA		11	14
Manitoba:	Winnipeg	P	NA		4	10
New Brunswick:	Moncton	P	NA		12	9
Newfoundland:	St. John's	P	NA		13	16
Nova Scotia:	Halifax	P	NA		10	10
Ontario:	Ottawa	P	NA		3	6
	Sault Ste. Marie	P	NA		19	16
	Thunder Bay	P	NA		9	13
	Toronto	P	NA		4	7
	Windsor	P	NA		6	6
Quebec:	Montreal	P	NA		5	7
	Quebec	P	NA		10	14
Saskatchewan:	Regina	P	NA		4	8
	Saskatoon	P	NA		10	8
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NS	0	NS	9
Chile:	Santiago	P	0	0	0	0
Colombia:	Bogota	P	0	1	0	0
Ecudor:	Guayaquil	P	0	1	0	0
Jamaica:	Kingston	P	NS	2	NS	0
Puerto Rico:	San Juan [c]	P	NA	2	0	23
Venezuela:	Caracas	P	0	1	0	2
PMN network average [e]				4	1	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups,

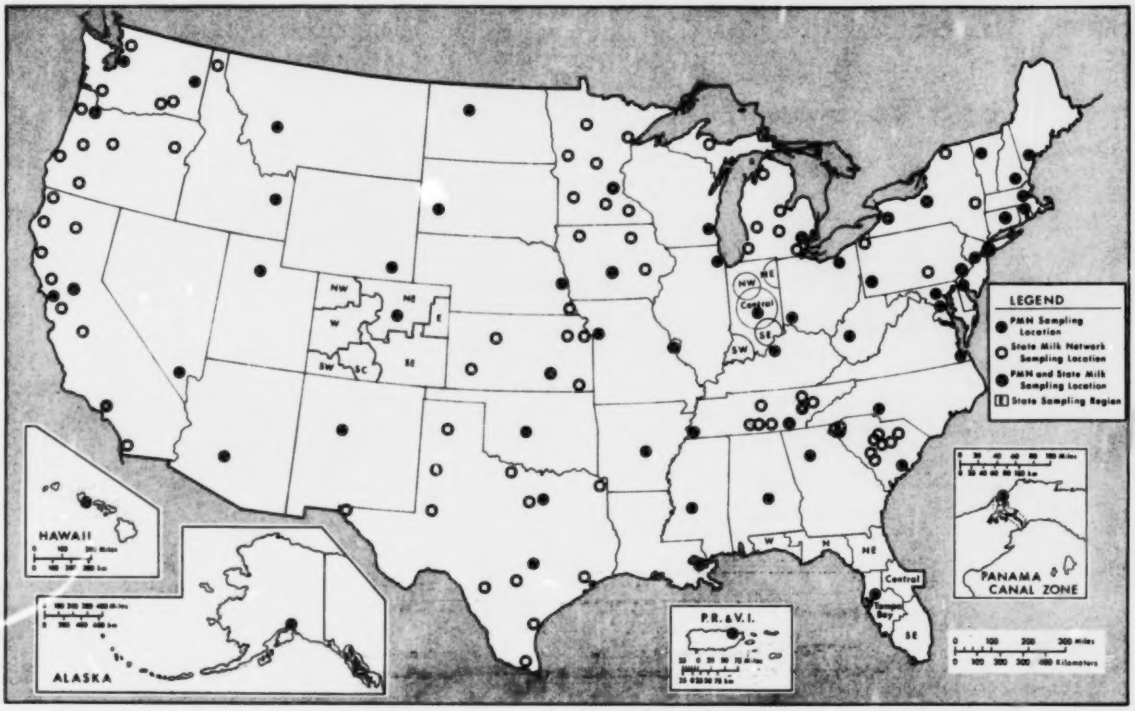

Figure 2. State and PMN sampling stations in the United States

averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for October 1973 and the 12-month period, November 1972 to October 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at most of the stations for October 1973 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 and iodine-131 were detected.

Table 3. Strontium-89 and iodine-131 in milk
October 1973

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Iodine-131
Kans:	Topeka (State)	5	
	Wichita (State)	7	
Minn:	Little Falls (State)		11
Colombia:	Bogota	7	

Strontium-90 monthly averages ranged from 0 to 31 pCi/liter in the United States for October 1973 and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 65 pCi/liter in the United States for October 1973, and the highest 12-month average was 50 pCi/liter (Southeast Florida) representing 1.4 percent of the value derived from the recommendations given in the Federal Radiation Council report. Table 4 gives the strontium-89 and strontium-90 results of PMN milk samples composited by region.

Table 4. Strontium-89 and strontium-90 results of PMN milk samples composited by region

EPA region	States located in region	Strontium-90 concentration (pCi/liter)
I	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	[a]4
II	New Jersey, New York, Puerto Rico	4
III	Delaware, District of Columbia, Maryland Pennsylvania, Virginia, West Virginia	8
IV	Alabama, Canal Zone, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	4
V	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	5
VI	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	6
VII	Iowa, Kansas, Missouri, Nebraska	5
VIII	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	2
IX	Arizona, California, Hawaii, Nevada	0
X	Alaska, Idaho, Oregon, Washington	3

[a] Strontium-89 was 6 pCi/liter. All other strontium-89 results were less than the practical reporting level (5 pCi/liter).

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Radiation Protection Bureau
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health
and Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Unit
Health Services Division
Washington Department of
Social and Health Services

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730-746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D. C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475-488 (September 1968).

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Milk Surveillance Network, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and 2 alternate sampling locations (figure 1) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from

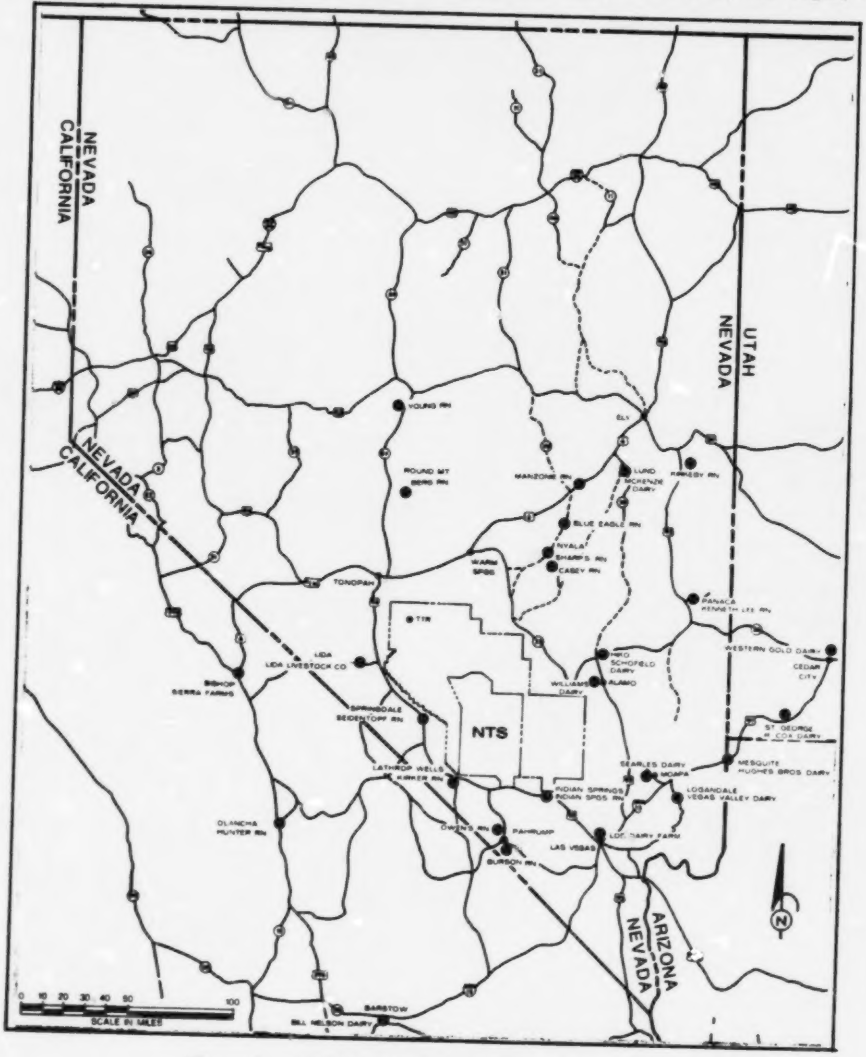

Figure 1. NERC-LV Milk Surveillance Network

the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested.

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Results

During nuclear testing at the NTS in October 1961, the Milk Surveillance Network was established with routine samples collected monthly. This sampling frequency was continued until October 1, 1973, when the collection frequency was changed to quarterly. This change was implemented to economize on operations and yet maintain adequate sampling capability in case of a release of radioactivity from the NTS. The sampling and analytical procedures which have not been changed with this revision of the network, are included with the milk results reported in the July 1973 issue of *Radiation Data and Reports*.

The analytical results of all milk samples collected in October 1973 by NERC-LV are listed in table 1. With the exception of cesium-

Table 1. Milk surveillance results, October 1973

Location	Date collected (1973)	Sample type[a]	Radionuclide concentrations[b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	24	11	<10	<2.0	1.8±1.2	NA
Hinkley:						
Bill Nelson Dairy	23	12	<10	<1.9	7.5±5.5	NA
Olancha:						
Hunter Ranch	24	13	<10	<1.8	<5.5	NA
Nevada:						
Alamo:						
Williams Dairy	1	12	<10	<2.0	<1.1	NA
Austin:						
Young's Ranch	8	13	<10	<2.0	2.5±1.4	630±250
Currant:						
Blue Eagle Ranch	9	13	<10	<2.0	2.3±1.2	NA
Manzonie Ranch	8	13	<10	<2.0	1.4±1.1	NA
Hiko:						
Schofield Dairy	1	12	[c] <100	<2.0	<1.1	<240
Indian Springs:						
Indian Springs Ranch	15	13	<10	<2.0	<1	NA
Las Vegas:						
LDS Dairy Farms	22	12	<10	<1.0	1.1± .80	<260
Lathrop Wells:						
Kirker Ranch	19	13	<10	<1.0	1.8± .90	NA
Lida:						
Lida Livestock Company	2	13	<10	<2.0	<1.2	NA
Logandale:						
Vegas Valley Dairy	16	12	<10	<2.0	2.5±1.2	NA
Lund:						
McKenzie Dairy	16	12	<10	<2.0	2.0±1.1	280±140
Mesquite:						
Hughes Bros. Dairy	16	12	<10	<2.0	1.3±1.1	300±240
Moapa:						
Searles Dairy	16	12	<10	<2.0	2.2±1.4	NA
Nyala:						
Sharp's Ranch	3	13	[c] <100	<1.0	<.9	<240
Pahrump:						
Owens Ranch	18	13	[c] <100	<2.0	1.7±1.0	NA
Panaca:						
Kenneth Lee Ranch	4	13	[c] <100	<2.0	<1.1	NA
Round Mountain:						
Berg Ranch	3	13	<10	<2.0	2.6±1.4	NA
Shoshone:						
Kirkeby Ranch	NS					
Springdale:						
Seidentopf Ranch	17	13	<10	<2.0	1.3±1.0	NA
Utah:						
Cedar City:						
Western Gold Dairy	17	12	<10	<2.0	2.0±1.3	NA
St. George:						
R. Cox Dairy	17	12	<10	<1.0	<.9	NA

[a] 11–Pasteurized milk.
12–Raw milk from Grade A producer(s).
13–Raw milk from family cow(s).

[b] Two-sigma counting error provided when available.

[c] Small sample size increased minimum detectable activity.

NA, no analysis.
NS, no sample.

137 at levels near the minimum detectable concentration (MDC) of 10 pCi/liter, no gamma emitting fission products were identified by gamma spectrometry in any of the samples collected in October 1973. Levels of tritium near the MDC for this radionuclide (~ 200 pCi/liter) were also measured by liquid scintillation counting techniques. The highest concentration of tritium during October 1973 was 630 ± 250 pCi/liter.

Pasteurized Milk Sampling in North Carolina January 1967 Through August 1973

Division of Facility Services[1]
North Carolina Department of
Human Resources

As part of its environmental radiation surveillance program, the Radiological Health Section of the North Carolina State Board of Health[1] began collecting pasteurized milk samples in 1964. From 1967 through 1972, there were seven sampling points in the State (figure 1). In January 1973, the Wilmington processing plant closed and milk processing for the area's dairies was transferred to Raleigh.

Pasteurized milk samples are collected monthly from the six milksheds in the State by county health department sanitarians. A representative sample is obtained for each milkshed by compositing milk from each dairy within the milkshed in proportion to each processing plant's volume. The 1 gallon sample is sent to the Department of Human Resources' Laboratory Section for analysis.

Upon arrival at the laboratory, the sample is transferred to a 3.5 liter polyethylene Marinelli beaker for gamma spectrum analysis for iodine-131, cesium-137, barium-140, and potassium-40. Gamma analysis utilizes a 4-inch NaI(Tl) detector and a Nuclear Data Model 130A 512-channel spectrometer. Gamma calculations are performed using the simultaneous equations method on an IBM-370 computer.

Following the gamma scan, the sample is processed for strontium-89 and strontium-90

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[1] On July 1, 1973, the Radiation Protection Program was transferred from the North Carolina State Board of Health to the new Division of Facility Services.

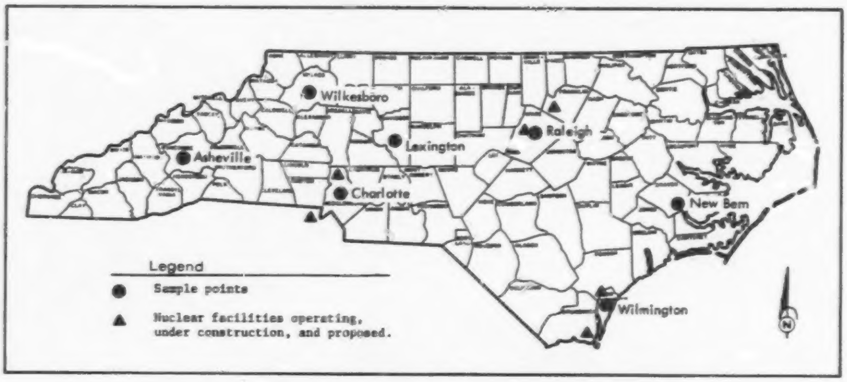

Figure 1. North Carolina milk sampling network

Table 1. Milk analysis results, North Carolina, 1967-1972

Year and location	Number of samples	Activity[a] (pCi/liter)	^{89}Sr	^{90}Sr[b]	^{131}I	^{137}Cs[c]	^{140}Ba
1967:							
Asheville	13	Maximum	ND	15.5	16.8	41.8	ND
		Average	ND	12.5	10.9	18.3	ND
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	5.8	18.8	31.6	44.3	24.5
		Average	5.1	14.9	12.5	24.5	11.1
		Minimum	ND	13.4	ND	13.6	ND
Lexington	13	Maximum	5.3	23.1	16.9	32.0	ND
		Average	5.0	16.8	10.7	17.8	ND
		Minimum	ND	14.0	ND	ND	ND
Charlotte	22	Maximum	7.1	18.5	39.1	54.4	12.4
		Average	5.1	15.8	11.1	17.2	10.1
		Minimum	ND	11.3	ND	ND	ND
Wilmington	12	Maximum	7.2	18.3	ND	38.9	ND
		Average	5.2	15.4	ND	22.8	ND
		Minimum	ND	12.2	ND	11.4	ND
Raleigh	13	Maximum	ND	18.5	27.4	29.2	14.3
		Average	ND	14.1	14.7	17.8	10.4
		Minimum	ND	10.9	ND	ND	ND
Wilkesboro	13	Maximum	7.9	26.0	18.3	30.1	10.6
		Average	5.2	18.3	11.5	20.0	10.0
		Minimum	ND	14.2	ND	10.2	ND
1968:							
Asheville	10	Maximum	ND	18.9	47.6	32.8	17.8
		Average	ND	13.8	21.1	18.1	10.6
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	ND	18.7	52.1	31.6	19.0
		Average	ND	15.2	20.9	21.5	10.8
		Minimum	ND	12.9	ND	13.0	ND
Lexington	8	Maximum	5.7	22.6	64.4	33.5	ND
		Average	5.1	17.2	25.4	19.7	ND
		Minimum	ND	14.0	ND	ND	ND
Charlotte	12	Maximum	ND	18.6	50.8	23.1	ND
		Average	ND	16.1	17.8	15.9	ND
		Minimum	ND	14.6	ND	11.3	ND
Wilmington	10	Maximum	5.2	16.1	43.7	37.9	ND
		Average	5.0	14.1	20.9	26.2	ND
		Minimum	ND	11.9	ND	15.5	ND
Raleigh	12	Maximum	ND	14.9	47.5	35.9	ND
		Average	ND	13.4	16.1	16.1	ND
		Minimum	ND	10.6	ND	ND	ND
Wilkesboro	12	Maximum	ND	24.7	50.7	31.5	ND
		Average	ND	18.9	26.2	19.8	ND
		Minimum	ND	14.5	ND	ND	ND
1969:							
Asheville	10	Maximum	5.9	14.9	34.5	21.4	37.7
		Average	5.1	11.3	12.0	15.6	12.3
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	7.6	15.5	ND	36.0	ND
		Average	5.2	11.9	ND	18.6	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	9	Maximum	13.8	18.7	30.2	40.3	ND
		Average	6.2	13.2	12.2	16.7	ND
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	9.0	21.2	ND	18.3	ND
		Average	5.3	14.3	ND	14.6	ND
		Minimum	ND	ND	ND	ND	ND
Wilmington	12	Maximum	ND	15.0	ND	39.7	ND
		Average	ND	12.0	ND	23.8	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	12	Maximum	ND	14.7	ND	20.7	ND
		Average	ND	11.3	ND	13.3	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	12	Maximum	5.2	21.9	ND	24.4	ND
		Average	5.0	16.7	ND	15.8	ND
		Minimum	ND	ND	ND	ND	ND
1970:							
Asheville	12	Maximum	ND	ND	32.6	20.9	15.4
		Average	ND	ND	13.9	14.9	10.7
		Minimum	ND	ND	ND	ND	ND
New Bern	12	Maximum	ND	11.5	14.9	29.0	ND
		Average	ND	10.2	10.4	16.2	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	12	Maximum	ND	12.6	49.6	24.0	18.9
		Average	ND	10.6	15.9	13.5	11.3
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	5.2	13.2	49.8	27.3	21.6
		Average	5.0	10.7	12.1	13.8	10.8
		Minimum	ND	ND	ND	ND	ND
Wilmington	10	Maximum	ND	10.8	15.1	23.9	ND
		Average	ND	10.1	10.5	18.0	ND
		Minimum	ND	ND	ND	11.2	ND

See footnotes at end of table.

Table 1. Milk analysis results, North Carolina, 1967-1972—continued

Year and location	Number of sample	Activity[a] (pCi/liter)	^{89}Sr	^{90}Sr[b]	^{131}I	^{137}Cs[c]	^{140}Ba
Raleigh	12	Maximum	ND	10.8	19.5	20.6	12.9
		Average	ND	10.1	10.8	13.9	10.2
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	11	Maximum	5.6	15.9	19.8	23.0	19.8
		Average	5.1	11.4	11.9	12.7	10.8
		Minimum	ND	ND	ND	ND	ND
1971:							
Asheville	14	Maximum	5.5	11.0	49.7	37.7	ND
		Average	5.0	10.9	16.9	17.5	ND
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	6.8	14.9	30.8	26.7	ND
		Average	5.8	10.7	13.4	17.4	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	10	Maximum	5.9	14.9	25.7	24.2	16.9
		Average	5.1	10.5	13.9	16.8	11.8
		Minimum	ND	ND	ND	ND	ND
Charlotte	12	Maximum	8.5	14.9	25.9	25.9	14.3
		Average	5.3	11.2	14.0	17.4	10.4
		Minimum	ND	ND	ND	ND	ND
Wilmington	8	Maximum	5.2	13.9	16.5	27.0	ND
		Average	5.0	10.6	12.0	21.7	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	15	Maximum	6.0	12.6	16.1	21.0	ND
		Average	5.1	10.3	10.7	15.2	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	10	Maximum	9.5	12.4	23.9	17.8	16.4
		Average	5.5	10.5	12.8	16.3	10.6
		Minimum	ND	ND	ND	ND	ND
1972:							
Asheville	14	Maximum	ND	ND	36.2	16.9	16.3
		Average	ND	ND	15.1	8.8	10.5
		Minimum	ND	ND	ND	ND	ND
New Bern	13	Maximum	ND	ND	30.6	18.7	ND
		Average	ND	ND	10.8	11.5	ND
		Minimum	ND	ND	ND	ND	ND
Lexington	15	Maximum	ND	11.3	40.2	16.2	ND
		Average	ND	10.1	10.2	8.6	ND
		Minimum	ND	ND	ND	ND	ND
Charlotte	10	Maximum	ND	11.1	49.2	22.9	18.3
		Average	ND	10.1	16.6	9.0	11.0
		Minimum	ND	ND	ND	ND	ND
Wilmington	11	Maximum	ND	11.2	27.4	24.3	ND
		Average	ND	10.1	14.1	14.0	ND
		Minimum	ND	ND	ND	ND	ND
Raleigh	15	Maximum	ND	ND	23.3	20.2	ND
		Average	ND	ND	12.3	9.4	ND
		Minimum	ND	ND	ND	ND	ND
Wilkesboro	14	Maximum	ND	12.0	45.8	24.0	17.8
		Average	ND	10.3	18.6	12.2	11.1
		Minimum	ND	ND	ND	ND	ND

[a] Minimum detectable activities are: strontium-89, 5 pCi/liter; cesium-137, 11.2 pCi/liter; all other listed, 10 pCi/liter.

[b] A value of 10.0 pCi/liter is used for averaging when the level of activity is less than the minimum detectable activity (MDA) except when all samples are below the MDA.

[c] Gamma spectra data printout lists concentrations even when below the MDA. These data are used to compute averages for cesium-137.

ND, nondetectable, below minimum detectable activity.

analysis using the ion-exchange procedure—TBP extraction method and counted on a Beckman low-beta II gas-flow proportional counter.

Data are presented in table 1 for 1967 through 1972. Table 2 provides 1973 strontium-90 results and table 3 shows 1973 cesium-137 and barium-140 monthly results. Strontium-89, iodine-131 and the unlisted cesium-137 and barium-140 results were below practical reporting levels.

The highest yearly isotopic concentration during the report period occurred in 1968 when the iodine-131 average was 26.2 pCi/liter, representing 26.2 percent of the applicable Federal Radiation Council radiation protection guide. No other yearly isotopic average exceeded 10 percent of FRC guidelines. Strontium-90 and cesium-137 yearly concentrations have continued to decrease during the report period.

At the present time, the North Carolina environmental radiation surveillance program is

Table 2. Results of strontium-90 analysis of pasteurized milk samples, North Carolina, January-August 1973

Sampling location	Strontium-90 (pCi/liter)							
	January	February	March	April	May	June	July	August
Asheville	3.9	4.3	4.5	4.9	5.2	6.2	6.2	5.8
New Bern	6.7	4.8	8.2	6.2	7.0	5.5	6.5	6.4
Lexington	5.3	6.5	5.7	6.5	7.7	8.3	7.1	7.2
Charlotte	5.8	NS	7.1	6.9	6.1	6.0	NS	6.8
Raleigh	7.7	5.3	5.8	6.3	5.6	6.2	6.7	6.7
Wilkesboro	7.9	6.0	6.7	7.1	8.9	9.3	NS	9.0

NS, no sample.

Table 3. Results of cesium-137 and barium-140 analyses of pasteurized milk above practical reporting levels North Carolina, January-August 1973

Sampling location	Month (1973)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Asheville	January	(a)	12.5
New Bern	August	(a)	24.5
Lexington	August	16.6	28.2
Charlotte	August	(a)	22.5
Wilkesboro	August	11.6	19.9

(a) Below 10 pCi/liter.

beginning to shift emphasis from background to nuclear facility oriented sampling. When the milk sampling network was established, there were no nuclear facilities operating in the State. There are now two operating, two under construction, and three announced nuclear facilities in North Carolina. The location of these facilities is given in figure 1.

As nuclear power plants become operational, the nuclear facility surveillance network will include raw milk sampling at appropriate points near each facility. These will be in addition to the pasteurized samples collected. The surveillance program will then be able to determine the effect of individual nuclear facilities as well as the overall impact of radioisotopes in milk on the citizens of North Carolina.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Institutional Diet	January–March 1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

Estimated Daily Intake of Radionuclides in California Diets July 1971-December 1972

Radiologic Health Section, California State Department of Health

Since January 1964, the Radiologic Health Section, California State Department of Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to be-

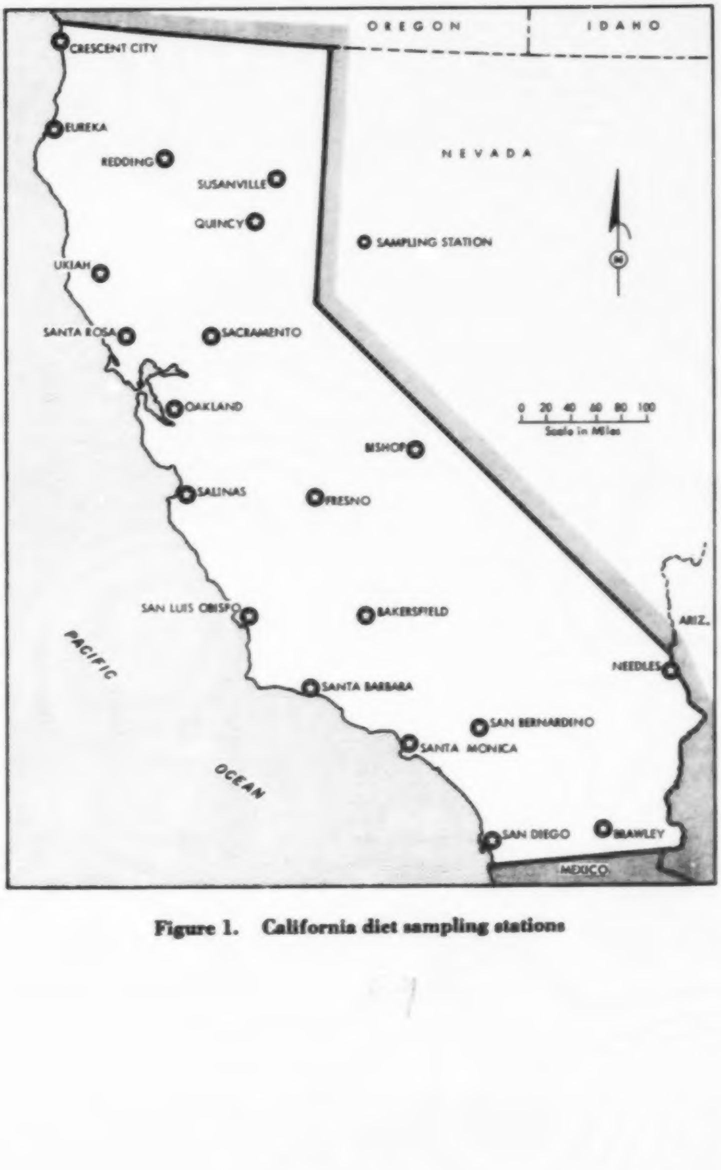

Figure 1. California diet sampling stations

lieve that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 3 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet), including liquids, for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, stable calcium, strontium, and sodium.

Table 1. Estimated daily intakes of radionuclides in California diets,[a] July-September 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	4	3	1.6	0	4	19	0	3.3	4.3	1.1
Bishop	1.9	5	4	1.9	1	2	17	0	2.7	2.8	1.0
Brawley	2.1	5	5	1.1	1	4	16	0	2.6	3.0	1.0
Crescent City	1.9	10	8	1.2	3	2	13	0	2.8	3.7	.7
Eureka	2.2	5	4	1.8	4	5	15	0	2.7	4.0	.8
Fresno	2.1	6	4	.4	9	0	6	0	3.1	3.4	1.0
Needles	2.2	3	4	1.3	0	6	14	0	2.3	2.5	.9
Oakland	2.1	3	5	1.5	4	5	17	0	2.8	3.5	.9
Quincy	2.1	14	4	2.5	1	7	14	0	2.4	3.0	.7
Redding	2.1	7	6	1.0	3	3	11	0	2.8	3.1	1.7
Sacramento	2.5	4	7	.4	11	0	0	0	3.1	4.7	1.0
Salinas	2.3	6	3	1.2	3	6	14	0	3.2	5.9	.7
San Bernardino	2.3	10	4	.6	14	0	0	0	3.4	4.5	1.2
San Diego	1.9	5	7	.8	7	10	23	0	2.9	2.9	1.5
San Luis Obispo	2.1	3	6	.8	0	2	21	0	3.1	3.5	1.1
Santa Barbara	2.0	5	7	1.2	11	0	1	0	2.6	3.7	1.4
Santa Monica	2.0	4	5	1.2	20	0	1	0	3.2	3.9	.9
Santa Rosa	1.7	5	5	1.8	11	0	3	0	2.3	4.0	.8
Susanville	2.2	5	3	.7	20	0	0	0	3.0	3.0	1.0
Ukiah	2.0	5	5	1.6	16	0	3	0	2.7	3.2	1.5

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141,144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 2. Estimated daily intakes of radionuclides in California diets,[a] October-December 1971

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	3	6	1.3	13	0	6	0	3.4	5.2	1.1
Bishop	1.8	2	6	1.4	11	1	1	0	2.5	2.7	.9
Brawley	1.7	2	6	1.0	7	0	1	0	2.3	2.7	1.2
Crescent City	2.2	2	12	1.1	14	0	4	0	2.8	3.8	.9
Eureka	1.9	5	5	2.7	8	0	1	0	2.3	4.2	.7
Fresno	2.2	3	5	1.1	9	0	1	0	3.2	3.0	1.0
Needles	2.5	5	6	.7	10	0	1	0	2.2	3.5	1.0
Oakland	.9	2	3	1.3	8	0	1	0	1.6	2.0	.3
Quincy	2.3	4	3	.9	13	0	11	0	3.1	3.3	.7
Redding	2.1	4	5	1.4	14	0	4	0	2.7	3.4	.8
Sacramento	2.2	9	7	1.2	11	0	1	0	2.8	4.8	.8
Salinas	2.3	1	8	1.1	16	0	5	0	3.2	5.9	.8
San Bernardino	1.9	4	5	1.2	11	0	0	0	2.6	3.4	1.0
San Diego	1.7	2	5	1.3	8	0	2	0	2.5	2.6	.8
San Luis Obispo	2.1	2	5	1.4	11	0	3	0	3.2	3.9	1.3
Santa Barbara	2.1	9	6	1.5	14	0	0	0	2.7	3.9	1.6
Santa Monica	2.0	4	5	1.5	15	0	0	0	3.2	4.2	.8
Santa Rosa	1.9	2	5	1.0	12	0	0	0	2.5	3.6	.9
Susanville	1.7	4	4	.6	12	0	0	0	1.8	2.9	1.1
Ukiah	1.1	3	5	1.0	6	0	1	0	2.2	2.6	.8

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141,144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 3. Estimated daily intakes of radionuclides in California diets,[a] January-March 1972

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	0	11	0.9	12	0	0	0	3.0	4.2	1.1
Bishop	1.7	2	5	.5	9	0	4	0	2.1	2.2	.7
Brawley	1.9	11	9	1.5	10	0	0	0	2.4	3.2	1.1
Crescent City	2.3	7	7	1.6	16	0	5	0	3.0	4.5	1.0
Eureka	2.2	8	8	2.4	12	0	1	0	2.9	3.9	1.3
Fresno	1.8	0	10	2.3	8	0	3	0	2.7	2.9	1.1
Needles	2.5	4	5	1.0	6	0	0	0	3.0	4.2	.8
Oakland	1.0	4	3	.9	7	0	2	0	1.8	1.8	.3
Quincy	2.2	5	4	.9	15	0	2	9	3.1	2.9	.7
Redding	2.3	4	9	.9	12	0	4	0	2.9	3.2	1.4
Sacramento	2.2	5	7	2.1	12	0	0	0	3.0	5.0	.9
Salinas	2.4	9	4	1.4	16	0	3	0	3.3	6.2	.8
San Bernardino	2.2	4	8	1.3	9	0	0	0	3.2	4.0	1.7
San Diego	2.2	4	8	1.6	8	0	2	0	3.5	3.2	1.0
San Luis Obispo	2.1	4	6	1.7	8	0	2	0	3.2	4.1	1.3
Santa Barbara	2.2	7	9	1.7	6	2	2	0	2.8	4.3	1.7
Santa Monica	1.9	4	5	1.2	5	0	3	0	2.6	3.5	.6
Santa Rosa	1.8	5	5	1.4	7	0	3	0	2.4	3.5	.8
Susanville	1.9	2	6	1.4	11	0	2	0	2.5	3.2	.9
Ukiah	.8	4	9	1.4	4	0	1	0	1.6	2.2	1.5

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 4. Estimated daily intakes of radionuclides in California diets,[a] April-June 1972

City	Consumption (kg/capita-day)[b]	Intake (µCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	6	4	1.6	8	2	1	0	3.2	4.8	1.1
Bishop	1.7	2	4	1.2	5	2	1	0	2.5	2.3	.8
Brawley	2.1	7	7	2.2	1	0	4	0	2.7	4.3	1.5
Crescent City	2.3	13	11	1.5	17	3	2	0	3.0	4.2	1.2
Eureka	2.3	9	8	2.0	10	0	3	0	2.8	4.2	1.0
Fresno	1.9	5	5	1.5	6	0	4	0	2.5	2.9	1.0
Needles	2.5	9	4	1.1	5	0	4	0	2.8	3.8	1.0
Oakland	.7	1	2	.3	0	1	0	0	1.0	1.2	.2
Quincy	2.4	9	4	.9	8	0	3	0	2.9	3.0	.8
Redding	1.9	2	6	1.1	10	0	2	0	2.5	4.0	1.3
Sacramento	2.5	9	6	1.5	4	5	3	0	3.4	5.4	1.0
Salinas	2.4	7	5	.8	3	1	2	0	3.1	5.5	.8
San Bernardino	2.1	6	4	.5	6	9	1	0	3.1	4.0	1.0
San Diego	1.9	4	5	1.1	4	0	4	0	2.7	2.8	1.0
San Luis Obispo	2.2	12	8	1.4	10	0	0	0	3.2	4.7	1.4
Santa Barbara	2.5	3	6	1.8	4	5	4	0	3.0	4.3	1.1
Santa Monica	1.5	5	3	.9	6	1	1	0	2.3	2.6	.6
Santa Rosa	1.9	3	5	1.0	6	1	6	0	2.3	4.0	.8
Susanville	1.8	5	4	.8	9	0	2	0	2.2	3.1	.9
Ukiah	.8	9	3	1.3	2	0	2	0	1.5	2.8	.7

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (July–September 1971), and table 2 (October–December 1971), table 3 (January–March 1972), table 4 (April–June 1972), table 5 (July–September 1972), and table 6 (October–December 1972).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through December 1972 is given in figures 2 and 3.

Table 5. Estimated daily intakes of radionuclides in California diets,[a] July-September 1972

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	13	5	1.1	11	3	3	0	3.4	4.7	1.3
Bishop	1.7	12	4	.9	10	3	0	0	2.7	2.6	1.0
Brawley	1.8	17	5	.9	5	1	6	0	2.5	3.8	.8
Crescent City	2.5	13	10	1.4	11	6	6	0	3.4	4.5	1.1
Eureka	2.3	12	6	1.2	13	8	2	0	2.7	4.7	.9
Fresno	2.0	14	4	1.2	5	1	6	0	2.7	2.9	1.1
Needles	2.2	14	5	.4	12	0	1	0	2.6	3.1	.8
Oakland	1.1	4	4	.4	10	2	1	0	1.2	2.7	.8
Quincy	2.1	14	4	1.3	8	4	1	0	2.9	2.7	.8
Redding	2.2	11	6	.8	10	2	2	0	2.6	3.6	1.6
Sacramento	2.5	12	5	1.4	5	2	4	0	3.4	5.9	.9
Salinas	2.5	15	11	1.7	10	1	6	0	3.4	7.2	.8
San Bernardino	1.9	12	5	1.4	7	3	0	0	2.2	3.0	1.4
San Diego	1.8	3	5	.8	3	3	0	0	2.5	2.8	.7
San Luis Obispo	2.2	4	3	.7	6	0	4	0	2.8	3.9	1.0
Santa Barbara	2.5	0	14	1.3	11	0	6	0	3.5	4.8	1.2
Santa Monica	2.4	12	2	1.2	11	0	4	0	3.0	3.1	1.2
Santa Rosa	2.0	0	17	.9	7	2	6	0	2.5	4.2	.9
Susanville	2.0	1	8	.6	6	0	2	0	2.3	2.8	.7
Ukiah	1.9	4	4	.3	8	0	2	0	2.4	3.7	.7

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

Table 6. Estimated daily intakes of radionuclides in California diets,[a] October-December 1973

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	2.3	2	5	.7	32	0	6	0	3.4	4.3	1.0
Bishop	1.9	2	5	.9	4	0	0	0	2.6	2.3	1.0
Brawley	1.8	4	9	.6	22	0	1	0	2.3	3.0	1.2
Crescent City	2.5	2	9	1.5	45	0	9	0	2.6	3.5	1.0
Eureka	2.2	3	4	1.0	49	0	7	0	2.8	4.6	.8
Fresno	1.9	0	5	.9	32	0	7	0	2.6	2.7	1.0
Needles	2.2	4	3	1.0	1	3	0	9	2.2	2.6	.7
Oakland	2.0	8	4	.6	37	0	2	0	2.3	2.4	.8
Quincy	1.7	1	3	.7	2	3	0	0	2.2	2.8	.6
Redding	2.0	3	4	.9	3	0	0	0	2.5	2.9	1.2
Sacramento	2.6	8	4	1.4	5	0	2	0	3.5	4.7	1.1
Salinas	2.4	10	5	1.4	4	1	2	0	3.3	7.8	.7
San Bernardino	2.1	9	5	1.1	4	0	3	0	2.8	3.4	1.9
San Diego	1.7	3	8	1.2	5	0	1	0	2.5	2.7	.8
San Luis Obispo	2.1	9	6	1.7	5	0	4	0	3.2	4.5	1.4
Santa Barbara	2.3	5	5	1.7	1	1	2	0	2.7	3.0	1.2
Santa Monica	1.8	6	4	.9	6	4	1	0	2.7	3.3	.8
Santa Rosa	2.3	3	4	.8	7	2	3	0	1.9	2.7	.8
Susanville	1.8	2	3	1.0	3	3	0	0	2.3	2.8	.8
Ukiah	1.9	2	8	.9	7	1	2	0	2.0	2.7	1.0

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet, including liquids.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis.

The practical reporting levels for these samples are: ^{89}Sr, 2.0 pCi/kg; ^{90}Sr, 1.0 pCi/kg; ^{226}Ra, 0.2 pCi/kg; ^{137}Cs, 7 pCi/kg; ^{95}Zr, 7 pCi/kg; ^{54}Mn, 7 pCi/kg; ^{141}, ^{144}Ce, 10 pCi/kg; and ^{40}K, 75 pCi/kg.

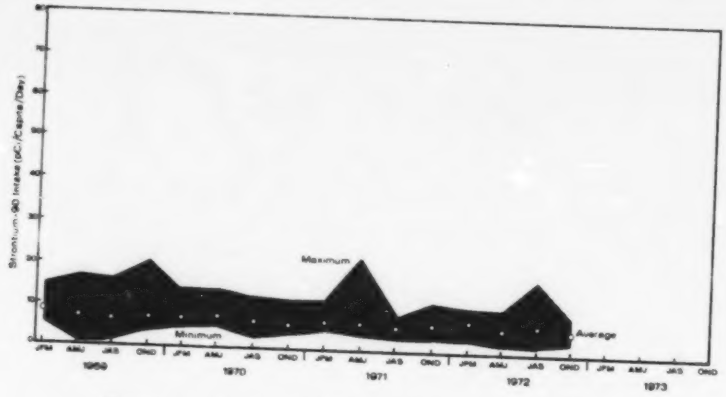

Figure 2. Average and ranges of strontium-90 intake in California diets

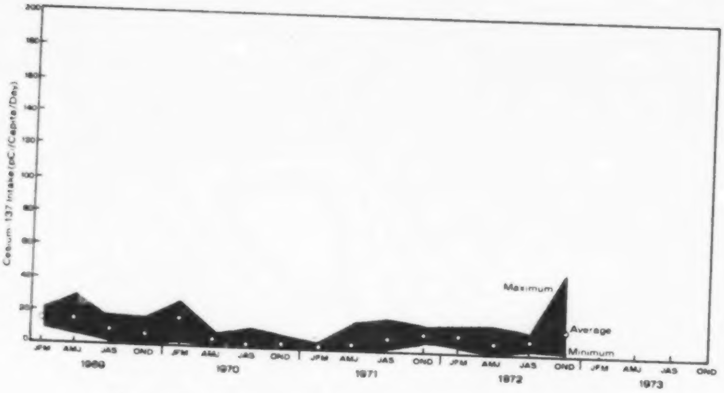

Figure 3. Average and ranges of cesium-137 intake in California diets

REFERENCE

(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley, Calif. 94704.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–June 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	January–December 1972	December 1973
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested.

During nuclear testing at the NTS in October 1961, the WSN was established with routine samples collected monthly. This sampling frequency was continued until October 1, 1973,

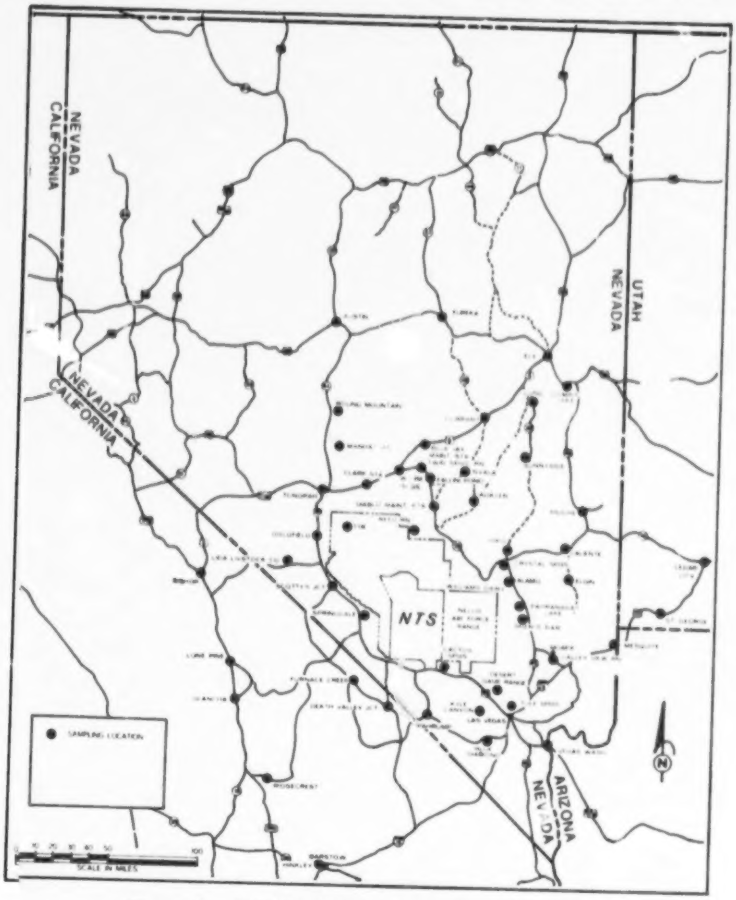

Figure 1. NERC-LV Water Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

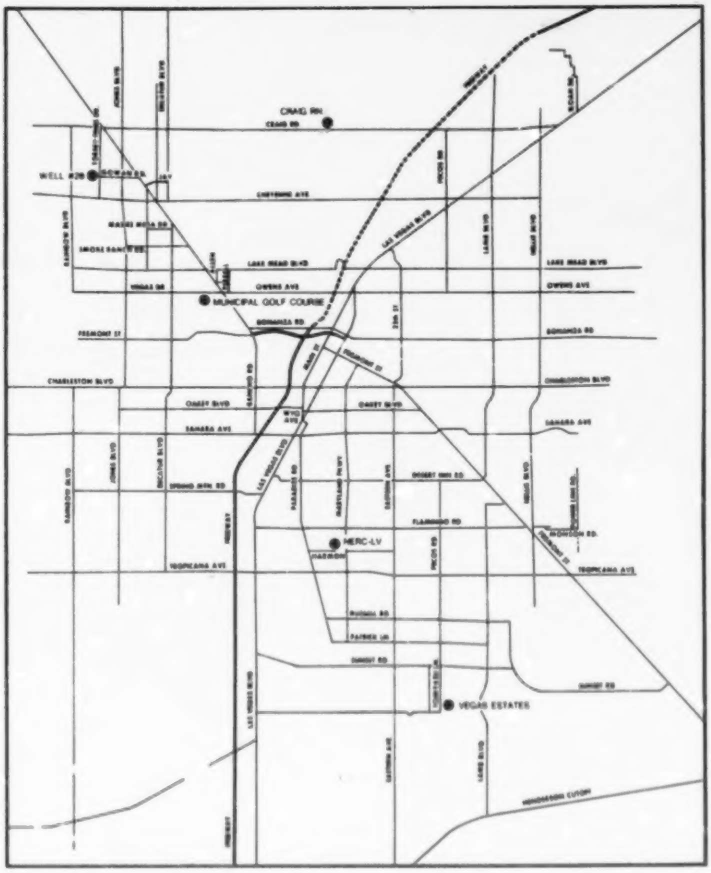

Figure 2. NERC-LV Water Surveillance Network-Las Vegas Valley

when the collection frequency was changed to quarterly. This change was implemented to economize on operations and yet maintain adequate sampling capability in case of a release of radioactivity from the NTS. The sampling and analytical procedures, which have not been changed with this revision of the WSN, are included with the water results reported in the July 1973 issue of "Radiation Data and Reports."

Results

The routine analytical results of all water samples collected in October 1973 by the NERC-LV water surveillance network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the samples.

Table 1. Water surveillance results, October 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	24	23	<1.3	<3.2	NA
Death Valley Junction:					
Lila's Cafe	25	23	<4.5	10 ±3.9	<240
Furnace Creek:					
Pond	25	21	<3.7	8.7±3.7	NA
Visitor Center	25	27	<3.6	[illegible].1±3.7	NA
Hinkley:					
Bill Nelson Dairy	23	23	7.3±4.8	6.9±3.6	NA
Lone Pine:					
Forest Service Ranger Station	24	24	1.8±1.7	<3.2	NA
Olancha:					
Haiwee Reservoir	24	21	6.3±4.1	5.6±3.4	NA
Ridgecrest:					
City Hall	24	23	<3.0	<3.3	NA
Nevada:					
Adaven:					
Canfield Ranch	3	22	<2.7	3.2±32.	NA
Alamo:					
Pahranagat Lake	5	21	19 ±8.4	35 ±5.1	NA
Sheri's Bar	5	23	<2.2	3.9±3.3	NA
Williams Dairy	1	23	5.0±4.4	9.4±3.7	NA
Austin:					
Nevada National Bank	4	27	23 ±6.7	14 ±3.8	NA
Blue Diamond:					
Post Office	16	23	<2.5	<3.3	<260
Blue Jay Highway:					
Maintenance Station	10	23	4.9±3.7	5.7±3.4	NA
Cactus Springs:					
Mobil Service Station	15	27	3.7±2.5	<3.3	<260
Caliente:					
Agricultural Extension Station	4	23	5.3±3.5	7.2±3.5	NA
Clark Station:					
Five Mile Ranch	11	27	<2.0	4.1±3.3	NA
Currant:					
Currant Ranch Cafe	10	27	8.9±4.8	<3.3	NA
Diablo:					
Highway Maintenance Station	2	23	<1.9	5.7±3.4	NA
Reed Ranch	1	21	14 ±6.4	17 ±4.1	NA
Elgin:					
Water tower	4	23	<3.5	7.6±3.6	NA
Ely:					
Chevron Service Station	16	24	4.2±2.8	3.1±3.1	NA
Comins Lake	16	21	8.3±4.4	15 ±4.0	NA
Eureka:					
Highway Maintenance Station	1	24	5.2±3.9	5.4±3.4	NA
	4	24	7.1±4.1	7.2±3.5	NA
Goldfield:					
Chevron Service Station	3	23	6.7±4.7	8.6±3.3	NA
Hiko:					
Crystal Springs	1	27	5.4±3.6	4.9±3.3	NA
Schofield Dairy	1	23	24 ±8.3	27 ±4.6	NA
Las Vegas:					
Craig Ranch Golf Course	23	23	10 ±4.3	4.0±3.3	<260
Desert Game Range	15	23	2.8±2.7	<3.1	<260
Lab II NERC	23	24	<3.5	7.0±3.6	930±270
Lake Mead Vegas wash	23	21	5.6±4.4	5.8±3.5	980±270
Las Vegas Water District Well 28	23	23	5.4±3.2	3.9±3.2	<260
Municipal Golf Course	23	23	3.1±2.5	<3.3	<260
Tule Springs	15	23	<2.4	<3.1	<260
Tule Springs Pond	15	21	4.8±2.8	<3.3	NA
Vegas Estates	23	23	4.6±4.4	12 ±4.0	<260
Lida:					
Lida Livestock Company	3	27	<2.4	<3.2	NA
Pond at storage tank	3	21	<2.4	5.9±3.4	NA
Lund:					
Gardner Grocery	17	23	<1.8	3.8±3.3	NA
Manhattan:					
Country store	4	23	9.5±5.3	4.3±3.3	NA
Mesquite:					
Hughes Bros. Dairy	16	23	<3.5	4.7±3.4	NA
Moapa:					
Pedersen Valley View Ranch	16	27	<3.9	10 ±3.7	NA
Mt. Charleston:					
Kyle Canyon Fire Station	15	27	2.9±2.5	<3.3	<260
Nyala:					
Sharp's Ranch	3	23	<2.1	<3.2	NA
Pahrump:					
Texaco Service Station	16	23	3.7±2.3	<3.3	NA

See footnotes end of table.

Table 1. Water surveillance results, October 1973—continued

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Pioche:					
County Courthouse	3	24	<2.0	4.9±3.3	NA
Round Mountain:					
Mobile Service Station	4	27	<2.2	<3.2	NA
Scotty's Junction:					
Chevron Service Station	3	23	<3.9	9.5±3.7	<240
Springdale:					
Pond	17	21	4.8±4.1	8.8±3.7	NA
Sunnyside:					
Adam McGill Reservoir	17	21	5.0±3.5	3.9±3.2	NA
Wildlife Management Headquarters	17	27	3.9±2.7	<3.3	NA
Tonopah:					
Jerry's Chevron Station	4	23	6.1±3.8	5.0±3.3	NA
Tonopah Test Range CP-1	11	23	<3.4	3.7±3.3	NA
Warm Springs:					
Fallini's Pond	3	21	6.5±4.9	13 ±3.9	NA
Service Station and Cafe	11	27	18 ±8.3	28 ±4.8	NA
Twin Springs Ranch	3	23	<3.2	5.9±3.4	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	17	24	<2.0	<3.1	NA
St. George:					
R. Cox Dairy	17	24	1.8±1.6	<3.2	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California Department

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*
of Health

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring program	January–June 1973	December 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1971	September 1973

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1. Radiation Alert Network
October 1973

Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All field estimate results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during October 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

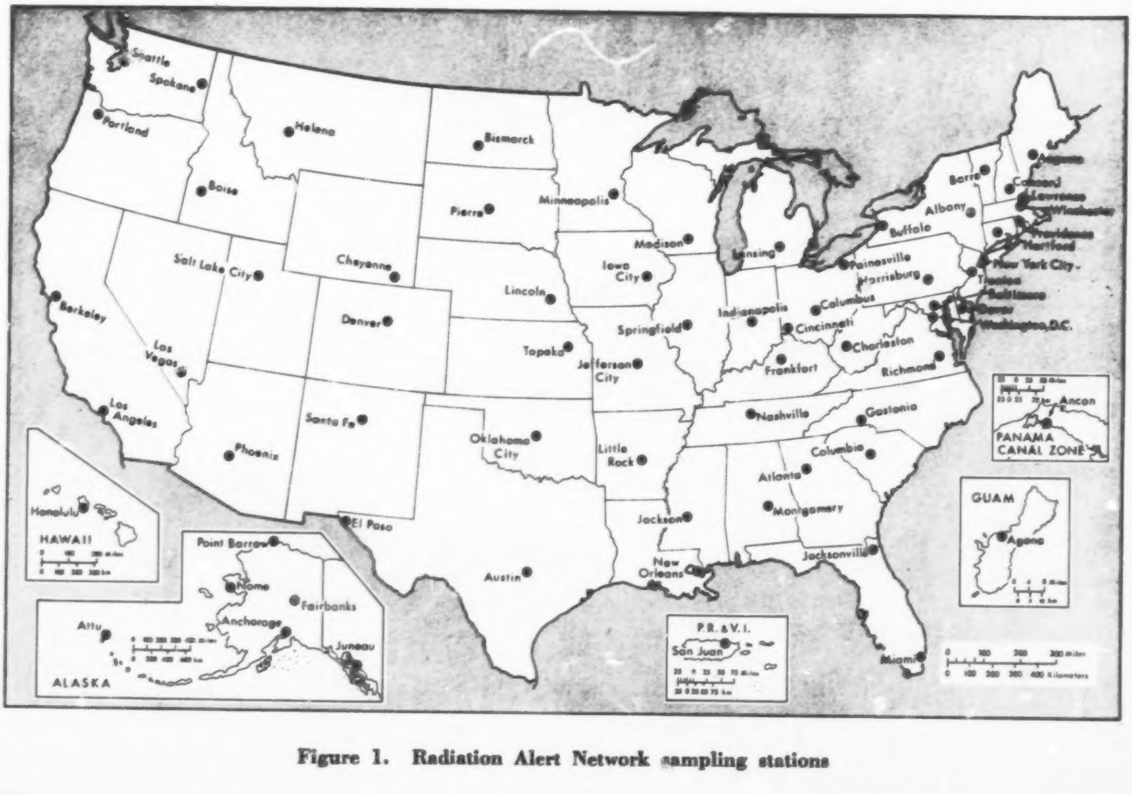

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1973

Station location [a]		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average[b]	Maximum	Minimum	Average [b]	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	14	6	0	2	0.05	<0.01	0.02	10	0.05
Alaska:	Anchorage	1				.02	.02	.02		
Calif:	Berkeley	9	0	0	0	.10	<.01	.04		
	Los Angeles	9	2	0	1	.07	.02	.04	9	.02
Colo:	Denver	9	2	1	1	.05	.02	.04	10	.06
Ind:	Indianapolis	19	2	0	1	.07	<.01	.03		
Nev:	Las Vegas	9	1	0	1	.04	.02	.03		
N. Mex:	Santa Fe	4	1	1	1	.03	.03	.03		
N.Y:	Buffalo	9	1	0	0	.06	.01	.03		
N. Dak:	Bismarck	9	7	0	1	.09	.01	.04	44	.25
Ohio:	Columbus	3	1	0	1	.03	.02	.03		
Okla:	Oklahoma City	4	1	0	1	.02	.01	.02		
Oreg:	Portland	22	1	0	0	.10	<.01	.02		
Pa:	Harrisburg	20	3	0	1	.06	.01	.03		
S.C:	Columbia	9	2	0	1	.04	<.01	.03	29	.07
Tex:	Austin	2	2	1	2	.01	.01	.01		
Network summary		148	7	0	1	0.10	<0.01	0.03	20	0.09

[a] The remaining stations are standby stations.
[b] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.

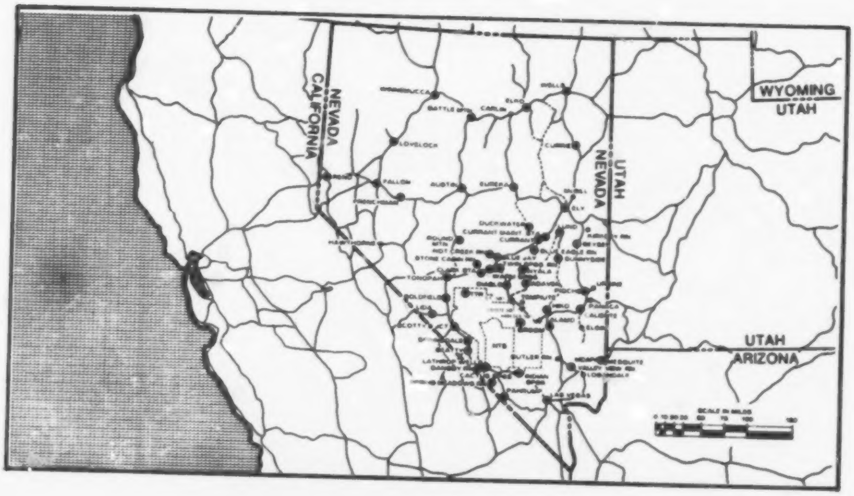

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

2. Air Surveillance Network, October 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Air Surveillance Network (ASN),[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 Western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health lepartment personnel and by private individuals on a contract basis. All active stations are perated continuously with filters being changed over periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to 2 significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (~0.03 pCi/m^3 for a 700 m^3 sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are indicated as follows:

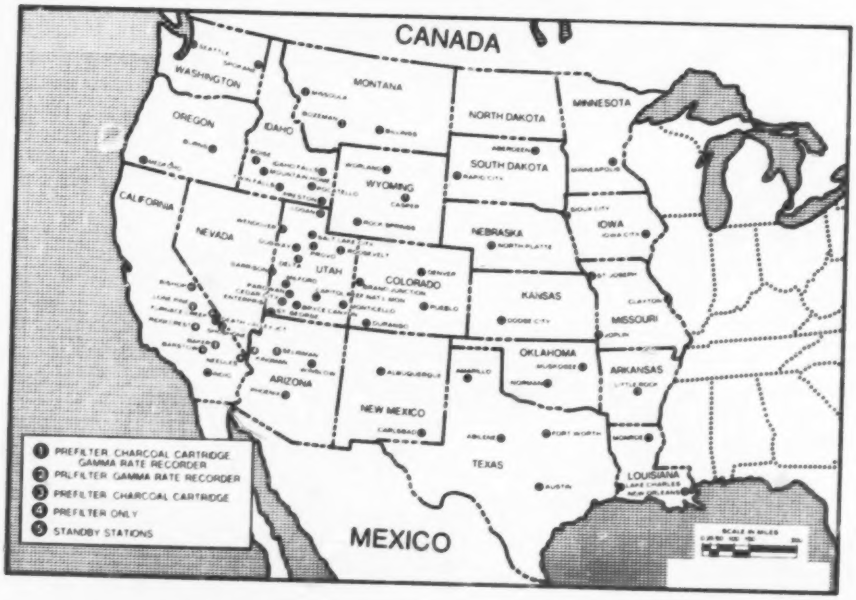

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

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[1] The ASN is operated under a Memorandum of Unrstanding (No. AT(26-1)-539) with the Nevada Operions Office, U.S. Atomic Energy Commission.

Concentration (pCi/m³)	Reported value of concentration above MDC (pCi/m³)	Reported value of concentration below MDC (pCi/m³)
<0.05	<0.1	<0.1
≧0.05 <0.15	0.1	<0.1
≧0.15	As calculated and rounded	<calculated MDC

As shown by table 2, the highest gross beta concentration at continuously operated stations within the network was 0.3 pCi/m³ at Caliente, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during October.

The 72 standby stations were activated on September 28 for one week of operation to check equipment and gather background radiation data. This activation resulted in two samples being collected at most of the standby stations during October 1973.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, October 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	0.2	<0.1	0.1
	Phoenix	12	.1	<.1	<.1
	Seligman	14	.1	<.1	.1
	Winslow	2	<.1	<.1	<.1
Ark:	Little Rock	3	<.1	<.1	.1
Calif:	Baker	23	.1	<.1	.1
	Barstow	14	.2	<.1	.1
	Bishop	14	.2	<.1	.1
	Death Valley Junction	13	.1	<.1	.1
	Furnance Creek	14	.1	<.1	.1
	Indio	5	<.1	<.1	<.1
	Lone Pine	12	.1	<.1	.1
	Needles	13	.1	<.1	.1
	Ridgecrest	13	.1	<.1	.1
	Shoshone	14	.1	<.1	.1
Colo:	Denver	2	<.1	<.1	<.1
	Durango	2	.1	<.1	<.1
Idaho:	Boise	2	.1	<.1	.1
	Idaho Falls	2	.1	<.1	.1
	Preston	2	.1	<.1	.1
	Twin Falls	2	.4	.2	.3
Iowa:	Iowa City	2	<.1	<.1	<.1
	Sioux City	2	<.1	<.1	<.1
Kans:	Dodge City	2	<.1	<.1	<.1
La:	Monroe	2	<.1	<.1	.1
	New Orleans	4	<.1	<.1	.1
Minn:	Minneapolis	2	<.1	<.1	<.1
Mo:	Clayton	2	<.1	<.1	<.1
	Joplin	2	<.1	<.1	<.1
Nebr:	North Platte	2	<.1	<.1	<.1
Nev:	Alamo	15	.1	<.1	.1
	Austin	8	<.1	<.1	<.1
	Battle Mountain	2	<.1	<.1	<.1
	Beatty	15	.2	<.1	.1
	Blue Eagle Ranch (Currant)	14	.1	<.1	.1
	Blue Jay	14	.2	<.1	.1
	Caliente	12	.3	<.1	.1
	Currant Ranch	14	.1	<.1	<.1
	Currie	2	.1	<.1	.1
	Diablo	14	.1	<.1	.1
	Duckwater	16	.1	<.1	.1
	Elko	2	.1	<.1	.1
	Ely	14	.1	<.1	<.1
	Eureka	14	.1	<.1	<.1
	Fallini's Twin Springs Ranch	14	.1	<.1	.1
	Fallon	2	.1	<.1	.1
	Frenchman Station	2	.1	.1	.1
	Geyser Ranch	13	.1	<.1	.1
	Goldfield	14	.1	<.1	.1
	Groom Lake	9	.2	<.1	.1

Table 2. Summary of gross beta radioactivity concentrations in air October 1973—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Nev:	Hiko	14	0.1	<0.1	0.1
	Indian Springs	14	<.1	<.1	<.1
	Las Vegas	13	.2	<.1	.1
	Lathrop Wells	17	.1	<.1	.1
	Lida	22	.1	<.1	.1
	Lovelock	2	.1	<.1	.1
	Lund	14	.1	<.1	.1
	Mesquite	14	.1	<.1	<.1
	Nyala	14	.1	<.1	.1
	Pahrump	14	.1	<.1	.1
	Pioche	14	.1	<.1	<.1
	Reno	2	.1	<.1	.1
	Round Mountain	14	.1	<.1	<.1
	Scotty's Junction	14	.1	<.1	.1
	Stone Cabin Ranch	14	.2	<.1	.1
	Sunnyside	11	.1	<.1	<.1
	Tonopah	14	.1	<.1	.1
	Tonopah Test Range	14	.1	<.1	.1
	Warm Springs	11	.1	<.1	.1
	Warm Springs Ranch	14	.1	<.1	.1
	Wells	2	.1	<.1	.1
	Winnemucca	2	.1	<.1	.1
N. Mex:	Albuquerque	4	.1	<.1	.1
	Carlsbad	3	<.1	<.1	.1
Okla:	Muskogee	2	<.1	<.1	<.1
Oreg:	Burns	2	.1	<.1	.1
	Medford	2	<.1	<.1	<.1
S. Dak:	Aberdeen	2	<.1	<.1	<.1
	Rapid City	2	<.1	<.1	<.1
Tex:	Abilene	2	<.1	<.1	<.1
	Amarillo	2	<.1	<.1	<.1
	Austin	1	<.1	<.1	<.1
	Fort Worth	2	<.1	<.1	<.1
Utah:	Bryce Canyon	3	<.2	<.1	.1
	Cedar City	10	.1	<.1	.1
	Delta	25	<.2	<.1	.1
	Dugway	2	.1	.1	.1
	Enterprise	2	.1	<.1	.1
	Garrison	16	.1	<.1	.1
Utah:	Logan	2	.1	.1	.1
	Milford	14	.1	<.1	.1
	Monticello	2	<.1	<.1	<.1
	Parowan	2	.1	<.1	.1
	Provo	2	.1	<.1	.1
	Salt Lake City	2	.1	.1	.1
	St. George	27	.1	<.1	.1
	Vernal	2	<.1	<.1	<.1
Wash:	Seattle	1	<.1	<.1	<.1
	Spokane	3	<.1	<.1	<.1
Wyo:	Rock Springs	2	<.1	<.1	<.1
	Worland	2	.1	<.1	.1

3. Canadian Air and Precipitation Monitoring Program,[3] October 1973

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in Reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of ***Radiological Health Data and Reports***.

Surface air and precipitation data for October 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, October 1973

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.01	0.01	0.01	NS	NS
Coral Harbour	5	.01	<.01	.01	1.4	0.2
Edmonton	4	.02	.01	.01	13.3	.1
Ft. Churchill	4	.01	<.01	.01	8.2	.6
Fredericton	3	.02	.01	.01	7.8	.3
Goose Bay	3	.03	.01	.02	6.9	.5
Halifax	5	.03	.01	.02	5.0	.6
Inuvik	5	.02	.01	.01	16.5	.3
Montreal	5	.02	.01	.01	6.9	.4
Moosonee	5	.03	.01	.02	8.1	.3
Ottawa	1	.02	.02	.02	6.7	.7
Quebec	4	.02	.01	.01	2.7	.3
Regina	3	.02	.01	.01	69.6	.4
Resolute	4	.02	.01	.01	11.0	.7
St. John's, Nfld	NS	NS	NS	NS	1.3	.2
Saskatoon	3	.02	.01	.01	NS	NS
Sault Ste. Marie	3	.03	.02	.03	10.3	1.0
Thunder Bay	4	.04	<.01	.02	13.9	.9
Toronto	4	.02	.01	.02	8.3	1.2
Vancouver	4	.01	<.01	.01	14.8	1.7
Whitehorse	4	.02	<.01	.01	9.3	.2
Windsor	NS	NS	NS	NS	10.7	.6
Winnipeg	4	.02	.01	.02	20.0	.7
Yellowknife	3	.01	<.01	.01	9.5	.4
Network summary	84	0.04	<0.01	0.01	11.9	0.6

NS, no sample.

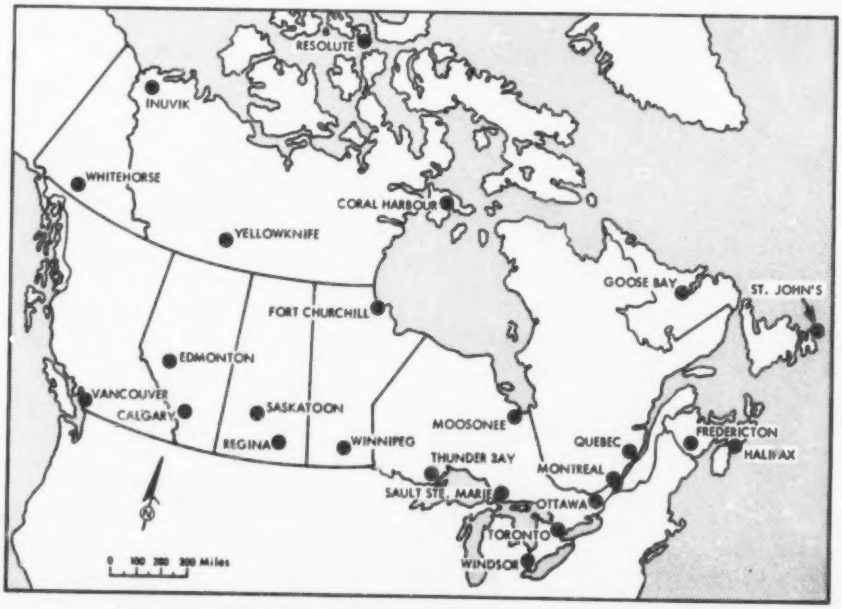

Figure 4. Canadian air and precipitation monitoring program

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

4. Pan American Air Sampling Program October 1973

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The October 1973 air monitoring results from the participating countries are given in table 4.

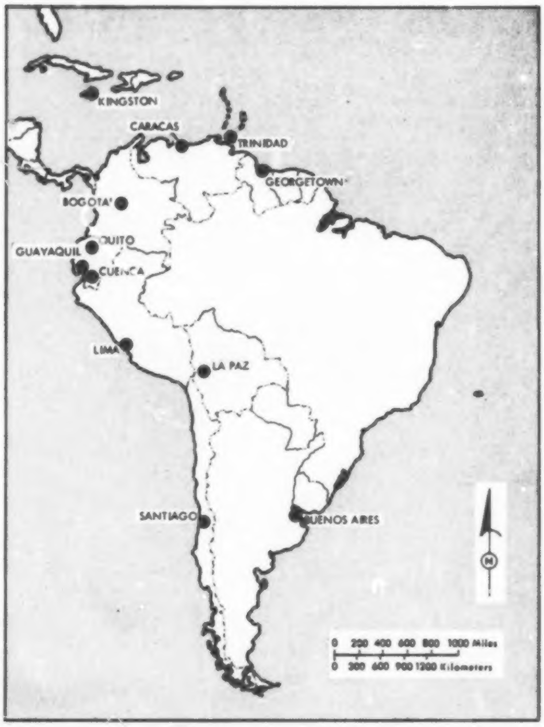

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, October 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	1	0.01	0.01	0.01
Chile:	Santiago	31	.07	.00	.01
Colombia:	Bogota	21	.08	.00	.00
Ecuador:	Cuenca	5	.02	.01	.01
	Guayaquil	20	.02	.00	.01
	Quito	19	.03	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	11	.01	.00	.01
West Indies:	Trindad	0			
Pan American summary		108	0.08	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program October 1973

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a con-

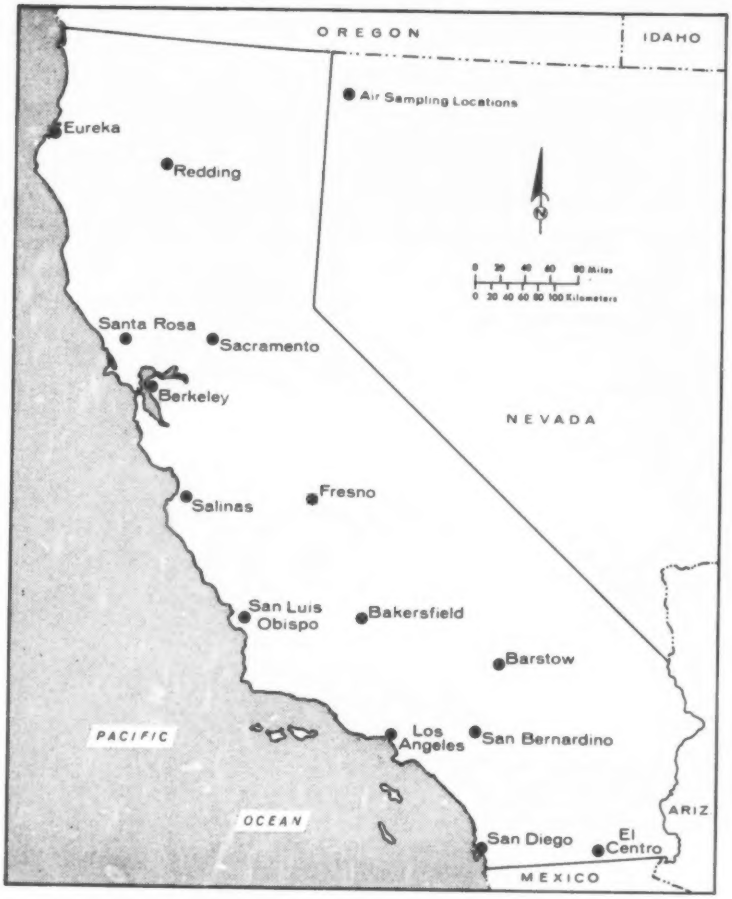

Figure 6. California air sampling program stations

tinuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for October 1973. The monthly sample results are presented quarterly.

Table 5. Gross beta radioactivity in California air October 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	30	1.29	0.05	0.27
Barstow	31	.76	.05	.20
Berkeley	30	.23	.00	.09
El Centro	14	.50	.04	.13
Eureka	30	.19	.01	.05
Fresno	30	1.20	.06	.19
Los Angeles	30	.21	.00	.07
Redding	28	.34	.06	.12
Sacramento	30	.96	.00	.16
Salinas	30	4.93	.14	.73
San Bernardino	30	.78	.07	.17
San Diego	30	.48	.00	.14
San Luis Obispo	30	.60	.01	.18
Santa Rosa	31	.42	.00	.11
Summary	404	4.93	0.00	0.19

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RDP-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Lawrence Berkeley Laboratory and the Savannah River Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Berkeley Laboratory[2]

January–December 1971

University of California
Berkeley, Calif.

The Lawrence Berkeley Laboratory (LBL) formerly known as the Berkeley site of the Lawrence Radiation Laboratory is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The major part of the Berkeley campus of the University of California is on the west. On the east are the Lawrence Hall of Science and the Space Sciences Laboratory; beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months, the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

The assessment of possible impact of the laboratory on its environment is carried out by two separate groups. All measurements of possible releases of radioactive materials to the environment are made by the Safety Services Department. Measurements of potential gamma and neutron exposures from the operation of

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[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Lawrence Berkeley Laboratory," January-December 1971, Berkeley, Calif.

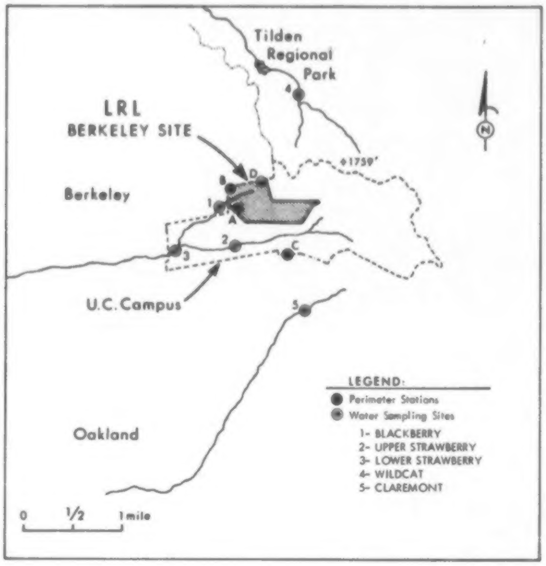

Figure 1. Environmental sampling locations at the Lawrence Berkeley Laboratory

the many accelerators are carried out by the Health Physics Department.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LBL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a 2½-inch thick paraffin-lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays.

At each station, total radiation levels are well below the standards set for the general public by the International Commission on Radiological Protection and National Council on Radiation Protection and Measurements (NCRP). Results are presented in table 1.

Atmospheric sampling

Our basic policy has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

Table 1. Neutron and gamma levels, Lawrence Berkeley Laboratory January-December 1971

Perimeter station	January-June		July-December	
	Total beta-gamma exposure (mrem) (background subtracted)	Total fast neutron exposure (mrem) [a] (background subtracted)	Total beta-gamma exposure (mrem) (background subtracted)	Total fast-neutron exposure (mrem) [a] (background subtracted)
A	9.75	85.6	7.21	182.4
B	9.74	35.8	(b)	16.8
C	(b)	13.0	4.39	.8
D	(c)	92.6	(c)	21.2

[a] 2.45×10^7 n/cm^2 = 1 rem.
[b] Detector not in service.
[c] Background.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. Our stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove box manifolds are sampled. The total quantities released from these stacks during January–June 1971 were 0.7 microcuries of alpha, 0.15 curies of carbon-14, 2.1 curies of tritium and 166 microcuries of other beta emitters. For the July–December period, the total quantities released were <0.1 microcuries of alpha, 8.3 millicuries of carbon-14, 5.9 curies of tritium and 55 microcuries of other beta emitters. The average concentration in the total exhaust, *before* any dilution by the atmosphere, was 9 percent for the January–June period and 6 percent for July–December period of the permissible concentrations for offsite breathing zone air as stated in the AEC standards.

In addition to the careful sampling of stacks, an environmental air sampling program is carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. Results from these samples are tabulated in some detail in table 2. The sampling stations designated "local area" are outdoor locations within the site boundaries and provide samples of the onsite atmosphere. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From these samples, it is apparent that there has been no significant exposure from radioactive materials released by LBL.

At each of these environmental stations, rain or dry "fallout" is also collected in 15-inch diameter containers. If no rain has fallen, the containers are rinsed out with water to obtain a sample. Table 3 shows a summary of atmospheric deposition. There is no indication that any of this originated at LBL.

Table 2. Atmospheric monitoring, LBL
January-December 1971

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m^3)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
January-June 1971:					
Local area (10)	249	0.000	<0.005	0.26	1.00
Perimeter					
A	26	.000	<.005	.24	.68
B	26	.000	<.005	.29	.86
C	26	.000	<.005	.28	.82
D	25	.000	<.005	.35	1.26
Summary	103	.000		.29	
July-December 1971:					
Local area (10)	247	.000	.006	.12	.42
Perimeter					
A	25	.000	.005	.18	.41
B	25	.001	<.005	.12	.29
C	23	.000	.005	.12	.30
D	25	.000	<.005	.17	.40
Summary	98	.000		.14	
AEC standard for offsite breathing zone air		0.020		10.0	

Table 3. Total deposition, LBL
January-December 1971

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m^2)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
January-June 1971:					
Local area (9)	54	0.019	0.062	6.199	7.72
Perimeter (4)	23	.015	.054	7.141	10.5
July-December 1971:					
Local area (9)	54	.027	.039	1.30	2.2
Perimeter (4)	24	.054	.073	3.60	7.33

Water sampling

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged accidentally. The average concentrations observed for January–December are shown in table 4. The total concentration (alpha-plus-beta) in sewage is ≤1 percent of the AEC standard for discharges to sewers.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as

Table 4. Summary of sewer data, LBL, January-December 1971

Location	Total quantities discharged 6 months			Number of samples	Net concentrations (pCi/liter)			
					Alpha		Beta	
	Total volume (Ml)	Total alpha radio-activity (μCi)	Total beta radio-activity (mCi)		Aver-age	Maxi-mum	Aver-age	Maxi-mum
January-June 1971:								
Hearst	131.0	8.6	4.73	21	0.07	2.0	36.1	550
Strawberry	54.6	12.0	1.06	24	.22	2.8	19.4	108
Summary	185.6	20.6	5.79		.11		31.2	
July-December 1971:								
Hearst [a]	144	34	1.41	15	.24	2.7	9.8	18
Strawberry	80	142	1.34	24	1.78	26	16.8	110
Summary	224	176	2.75		.79		12.3	
AEC standard for sewer discharges					400		3 000	

[a] The Hearst sewer sampler was inoperative for one-third of this period. Quantities reported are estimates made by assuming that the average concentrations during the down period were the same as when the sampler was operating.

Table 5. Water monitoring, Lawrence Berkeley Laboratory, January-December 1971

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Aver-age	Maxi-mum	Aver-age	Maxi-mum
January-June 1971:					
Surface water:					
Onsite streams:					
Blackberry	26	0.18	1.6	3.74	15.3
Lower Strawberry	26	.29	2.1	10.12	83.4
Upper Strawberry	26	0	1.2	2.67	9.6
Summary	78	.16		5.51	
Offsite streams:					
Claremont	26	.55	2.5	2.43	7.4
Wildcat	26	.12	3.8	2.10	7.6
Summary	52	.34		2.26	
Tap water	25	0	.48	1.52	2.6
July-December 1971:					
Onsite streams:					
Blackberry	25	.07	.7	2.70	8.8
Lower Strawberry	25	.23	1.6	6.99	17.1
Upper Strawberry	25	.30	1.5	3.26	8.8
Summary	75	.20		4.32	
Offsite streams:					
Claremont	25	.20	2.6	1.96	4.9
Wildcat	25	.07	.9	2.32	4.3
Summary	50	.13		2.14	
Tap water	23	.06	.5	1.52	2.8
AEC standard for offsite drinking water		30.0		100.0	

"onsite streams" in table 5. Two nearby offsite streams are also sampled to provide a comparison. All are very safely below the standard for drinking water.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July-December 1970	October 1971

2. Savannah River Plant[3]
January-December 1971

E. I. DuPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP) occupies an area of about 315 square miles along the Savannah River, principally in Aiken and Barnwell Counties of South Carolina. Most of the plant's environs are rural. Population density of nearby counties ranges from 10 to over 400 people per square mile with the greatest concentration in Augusta, Ga. and its suburbs, which has a population approaching 200 000. The countryside is predominantly forested. Farming is diversified, the main crops being cotton, soybeans, corn, and small grains. Production of beef cattle has rapidly expanded during the past few years. The climate is mild, with an average frost-free season of approximately 246 days. Rainfall averages about 45 inches that is fairly evenly distributed throughout the year.

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[3] Summarized from "Environmental Monitoring in the Vicinity of the Savannah River Plant," Annual Report for 1971 (DPSPU 72-30).

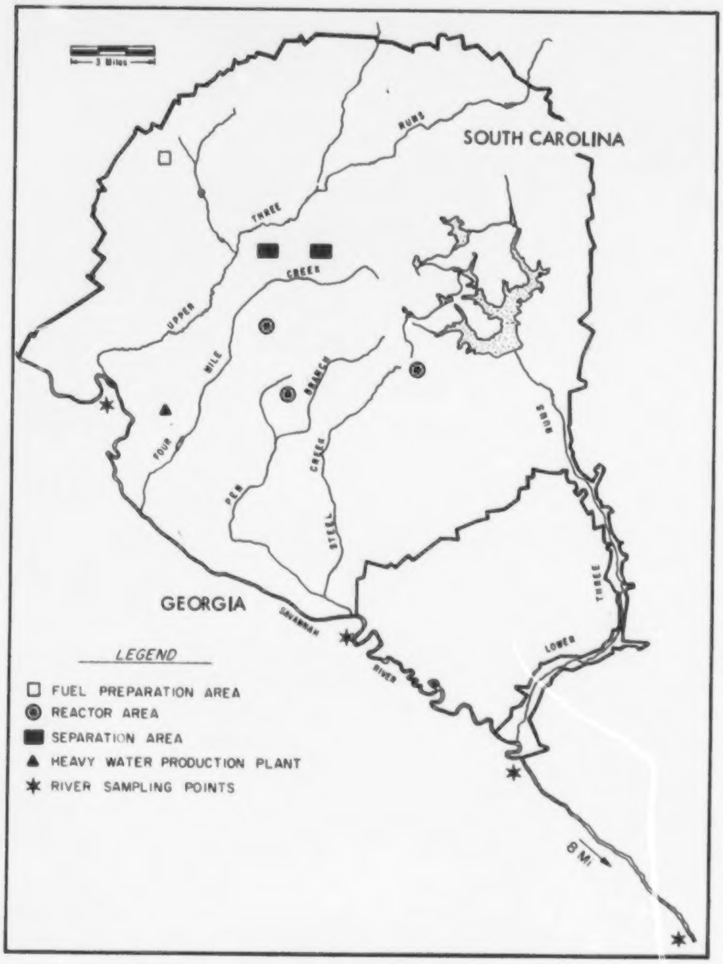

Figure 2. SRP production and effluent streams

SRP's primary function is the production of plutonium, tritium, and other special nuclear materials for the national defense, for other governmental uses, and for some civilian purposes. Production facilities now operating include three nuclear reactors, a fuel and target fabrication plant, two chemical separations plants, and a heavy water production plant. The reactors and separations plants are located near the center of the site; the other facilities near its periphery.

The reactors are fueled with uranium and moderated and cooled by heavy water which is circulated in a closed system through heat exchangers. Savannah River water and water from Par Pond, a manmade cooling lake, are used only as a secondary coolant in the heat exchangers. Water from the river or lake does not pass through the reactors, so is not subject to neutron activation.

Nuclear fuels and targets, together with other components necessary for the reactors, are manufactured in a fuel and target fabrication facility on the site. The operations are largely metallurgical and have relatively slight potential for release of radioactivity.

Reactor products are recovered in the fuel separations areas. Plutonium-239 and uranium are separated from each other and from fission products by complex chemical processes. Plutonium-238 and californium-252 are also important SRP products that are processed in the separations areas. These areas also have facilities for the purification and packaging of tritium, and for storage of fission product wastes.

The heavy water production plant separates and concentrates heavy water from the raw water of the Savannah River. The basic process for extraction of heavy water from river water is chemical exchange with hydrogen sulfide gas at about 300 psig pressure. Heavy water is not radioactive, but a portion of the heavy water production facility is used for the reconcentration of moderator from the reactors and this heavy water contains some tritium.

SRP production area and effluent streams are shown in figure 2.

Atmospheric Monitoring

Concentrations of radioactive materials in the atmosphere are measured by biweekly analysis of air filter contents collected at five monitoring stations near the plant (figure 3). Deposition rates of radioactive materials at each station are also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). All monitoring stations operate continuously and are spaced so that a significant release of airborne activity by SRP would be detected regardless of the prevailing wind. Four additional air monitoring stations at Savannah and Macon, Ga. and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; these serve as reference points for determining background activity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

Particulate airborne radioactivity is sampled continuously by drawing air through 2-inch diameter high-efficiency asbestos paper filters that are collected biweekly. The air is sampled at about 2.5 cubic feet per minute with an auxiliary running-time meter and air flow meter at each station providing data on the volume sampled. A cartridge of activated coconut charcoal for collection of gaesous radioiodine is located behind each paper filter. Moisture is concentrated from the atmosphere for determination of its tritium oxide content by pumping air through a silica gel column at a continuous rate of 100 cm^3/minute (operated off the manifold of each vacuum pump). The column contains nonindicating silica gel; a backup column of indicating silica gel is used for evidence of any saturation of the desiccant.

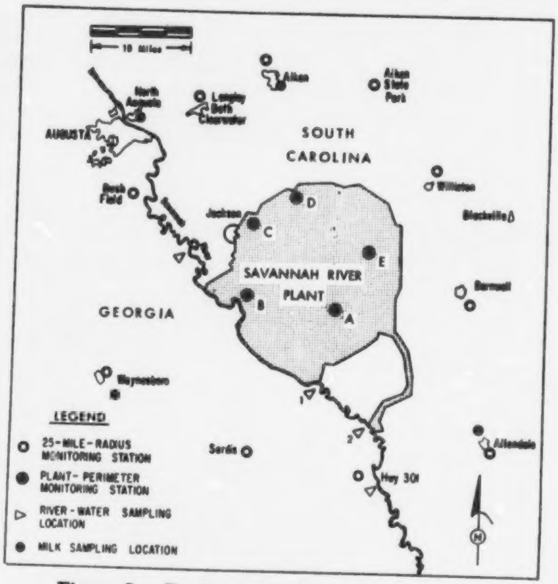

Figure 3. **Environmental sampling locations Savannah River Plant**

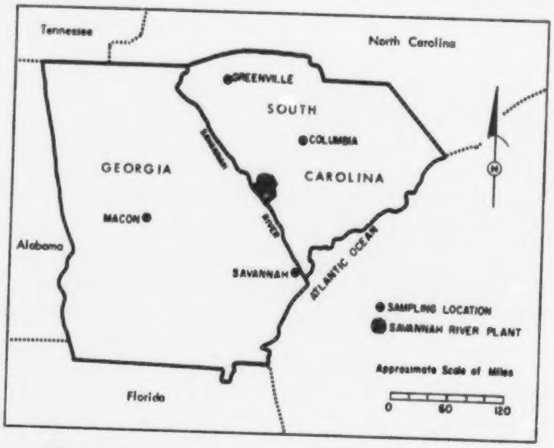

Figure 4. **Distant air monitoring stations, SRP**

The concentration of tritium oxide in the air is calculated from the concentration in atmospheric moisture and the absolute humidity.

Deposition rates of radioactive materials are also determined by monthly analyses of rainwater ion-exchange columns (fallout collectors). Fallout collection pans (2 feet by 2 feet) are located at each plant perimeter and 25-mile radius air monitoring station. Rain collected in the collection pan flows by gravity through an ion exchange column (cation and anion resin). The columns are analyzed directly by gamma spectrometry for gamma emitters. Alpha and beta emitters are removed from the column with acid (column elutrient) and analyzed by chemical methods. The rainwater passing through the ion exchange column is collected in a plastic jug for biweekly tritium analyses by liquid scintillation counting.

The small amount of particulate beta activity released to the atmosphere, primarily from the fuel separations area, is obscured in the area surrounding the plant by worldwide fallout. The influence of nuclear tests, which were resumed in September 1961, is shown in figure 5. The slightly increasing trend (1967 through 1971) is attributed to fallout from atmospheric testing by nonparticipants in the atmospheric testing moratorium. Some increase occurs each spring as a result of the mixing of radioactivity in the stratosphere with the troposphere. The average beta concentration in air decreased from 0.33 pCi/m^3 during the first half of 1971 to 0.12 pCi/m^3 during the last half of the year. The 1971 average is the same as that for 1970. The 1971 concentrations of particulate beta activity (0.23 pCi/m^3) and alpha activity (0.0008 pCi/m^3) in air were 0.2 percent and 4.0 percent of the AEC standards. Tritium oxide concentrations in air at the plant perimeter did not exceed 0.2 percent of the AEC standard. Iodine-131 in air samples at plant perimeter and 25-mile radius stations was less than the level of detection throughout the period (less than 1.5 percent of the AEC standard).

Gamma-emitting radionuclides observed in fallout are cesium-134, -137; cerium-141, -144; ruthenium-103, -106; and zirconium-niobium-

Table 6. Radioactivity in air, Savannah River Plant, January-December 1971

Sampling points	Alpha radioactivity [a] (fCi/m^3)			Nonvolatile beta radioactivity [b] (pCi/m^3)			Atmospheric moisture analysis Tritium [c] (pCi/m^3)		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Plant perimeter:									
A	2.7	0.4	0.8	0.70	0.05	0.24	450	60	200
B	2.1	.3	.9	.69	.04	.22	630	60	230
C	1.6	ND	.8	.74	.05	.24	280	20	80
D	1.3	ND	.8	.86	ND	.26	440	10	120
E	1.1	ND	.8	.68	.05	.23	720	30	180
Average			0.8			0.24			162
25-mile radius:									
Aiken Airport	1.7	ND	.7	.67	.05	.22	210	10	40
Aiken State Park	1.6	ND	.7	.75	.05	.20	190	10	50
Allendale	1.5	.3	.8	.76	.04	.22	140	10	30
Barnwell	1.8	ND	1.0	.66	.04	.22	190	10	60
Bush Field	1.3	.4	.8	.76	.04	.22	170	10	40
Langley	1.7	ND	1.0	.86	.04	.25	140	10	40
Sardis	1.2	ND	.7	.68	.04	.22	130	10	30
Waynesboro	1.4	.3	.8	.75	.04	.22	170	10	50
Williston	1.5	ND	.8	.71	.04	.22	320	10	60
Highway 301	1.3	ND	.8	.73	.04	.22	120	10	40
Average			0.8			0.22			44
Distant air-monitoring:									
S.C.									
Columbia	2.4	ND	1.0	.93	.03	.23			
Greenville	1.3	ND	.8	.65	.04	.24			
Ga.									
Macon	1.8	ND	.7	.66	.03	.20			
Savannah	1.8	ND	.6	.73	.03	.22			
Average			0.8			0.22			

[a] AEC radiation protection standard, 20 fCi/m^3; sensitivity of analysis, 0.3 fCi/m^3.
[b] AEC radiation protection standard, 100 pCi/m^3; sensitivity of anaysis, 0.006 pCi/m^3.
[c] AEC radiation protection standard, 200 nCi/m^3; sensitivity of analysis, 10 pCi/m^3.
ND, nondetectable, less than sensitivity of analysis.

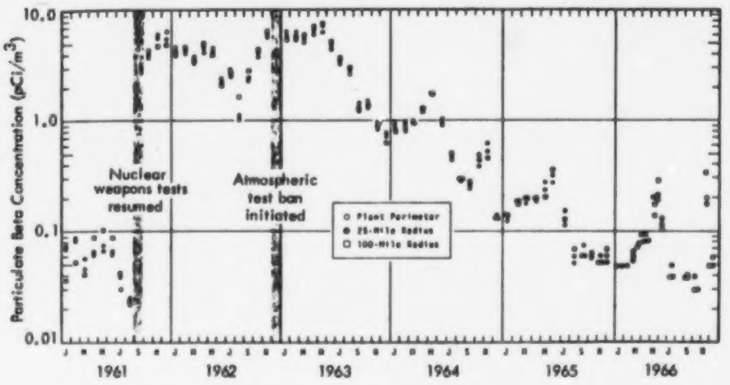

Figure 5. Influence of weapons tests

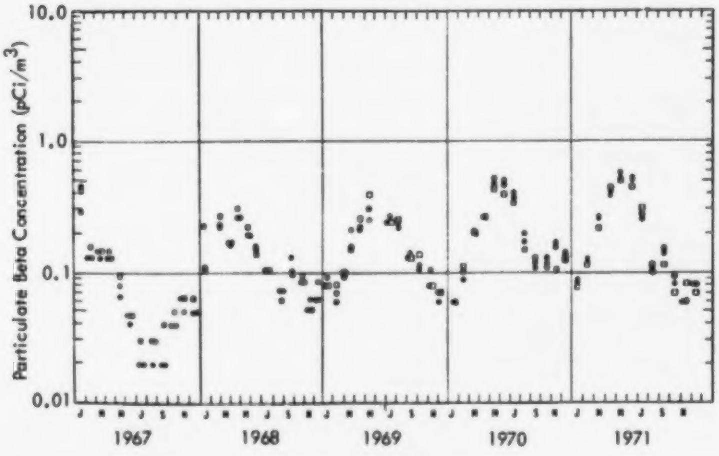

Figure 5. Influence of weapons tests—continued

95. Radioactivity in air, determined from filter analyses, is shown in table 6. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Plant releases of airborne radioactivity, with exception of tritium, are not detectable at the plant perimeter, and concentrations are calculated using standard meteorological dispersion equations, normalized to agree with measured dispersion of tritium.

Deposition of fallout, excluding beryllium-7, during 1971 averaged 47 nCi/m^2 at plant perimeter locations and 47 nCi/m^2 at 25-mile-radius locations; comparable values for 1970 were 30 and 38 nCi/m^2, respectively (table 7). Rainwater is analyzed biweekly for tritium, the average concentration at the plant perimeter is 6.0 nCi/liter as compared with 1 nCi/liter at 25-mile radius stations (table 7).

Monthly measurements of gamma radiation are made with thermoluminescent dosimeters

Table 7. Total fallout deposited, Savannah River Plant, January-December 1971

Sampling points	Total fallout deposited (nCi/m²)									Tritium in rainwater [a] (nCi/liter)		
	Alpha emitters	^{89}Sr	^{90}Sr	^{137}Cs	^{141,144}Ce	^{95}Zr-Nb	^{7}Be [b]	^{103,106}Ru	^{131}I	Maximum	Mini-Mum	Average
Plant perimeter:												
A	0.055	1.7	1.4	2.9	14.2	16.8	63.4	7.3	ND	16	3.0	8.0
B	.066	1.1	.9	2.4	15.7	16.3	65.3	6.8	ND	14	2.0	10
C	.071	2.2	1.3	3.1	18.9	15.9	76.4	8.1	ND	12	1.0	4.0
D	.058	2.4	1.2	2.9	14.7	17.4	60.0	7.5	0.5	15	ND	4.0
E	.065	2.3	1.4	2.9	18.9	21.1	71.9	6.1	ND	10	1.0	5.0
Average [c]	0.063	2.0	1.3	2.8	16.5	17.5	67.4	7.1	0.1			6.0
25-mile radius:												
Aiken Airport	0.074	2.2	1.6	3.3	19.8	29.6	75.4	6.5	ND	2.4	ND	1.1
Aiken State Park	.097	1.5	1.3	2.5	12.2	18.2	56.9	6.5	ND	3.7	ND	.40
Allendale	.065	2.7	1.2	2.9	16.1	24.1	64.4	5.8	ND	1.0	ND	.60
Barnwell	.064	1.8	.9	1.4	8.2	14.2	33.1	5.1	ND	4.6	ND	2.0
Bush Field	.108	.7	1.3	2.4	19.0	18.9	68.5	6.0	ND	2.2	ND	.80
Langley	.079	2.0	1.4	3.2	16.5	23.5	67.8	7.1	ND	1.1	ND	.80
Sardis	.121	1.3	1.2	2.7	12.3	25.0	50.5	5.9	ND	1.0	ND	.60
Waynesboro	.054	2.2	1.6	3.1	14.9	23.7	69.3	6.3	ND	3.0	ND	1.0
Williston	.070	2.1	1.3	2.7	13.1	19.9	61.2	5.5	ND	3.8	ND	1.8
Highway 301	.042	.8	1.4	2.1	8.7	12.6	39.7	5.8	ND	1.4	ND	.70
Average [d]	0.077	1.7	1.4	2.7	14.2	20.9	58.7	6.1	ND			1.0

[a] Sensitivity of analysis, 0.03 nCi/liter.
[b] A natural radionuclide (see foregoing section on "Atmospheric Monitoring").
[c] Average deposition of tritium, 816 μCi/m².
[d] Average deposition of tritium, 136 μCi/m².
ND, nondetectable, less than sensitivity of analysis.

at the plant perimeter and 25-mile radius locations. The 1971 environmental gamma radiation data (table 8) are characteristic measurements observed at individual stations for the past several years (~60 mR/year). SRP contribution to gamma radiation is so low as to be indistinguishable from normal variations in natural gamma radiation.

Table 8. Environmental gamma radiation, Savannah River Plant, January-December 1971

Sampling points	Gamma radiation	
	mR/day	mR/year
Plant perimeter:		
A	0.20	73.0
B	.16	58.4
C	.16	58.4
D	.16	58.4
E	.17	62.0
Average	0.17	62.0
25-mile radius:		
Aiken Airport	0.14	51.1
Aiken State Park	.14	51.1
Allendale	.14	51.1
Barnwell	.18	65.7
Bush Field	.18	65.7
Langley	.16	58.4
Sardis	.18	65.7
Waynesboro	.14	51.1
Williston	.18	65.7
Highway 301	.20	73.0
Average	0.16	59.8

Water monitoring

The SRP site is drained by five streams that flow several miles through the reservation before reaching the Savannah River (figure 2). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. Tritium accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the contribution of tritium to the Savannah River results in concentrations of only 0.2 percent of the AEC standard.

River water is sampled continuously above and below the plant and is analyzed weekly. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 9. The upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests. The downstream measurements reflect these sources plus releases from SRP.

Continuous sampling of the Savannah River is accomplished with a sampler consisting of a "Plexiglas" water wheel suspended on two pontoons. As the water wheel is turned by flowing water, a small cup (or cups) on one paddle picks

Table 9. Radioactivity in Savannah River water January-December 1971

Sampling points	Alpha radioactivity[a] (pCi/liter)			Nonvolatile beta radioactivity[b] (pCi/liter)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1 mile upstream from Upper Three Runs Creek (control)	0.5	ND	ND	12	ND	4
8 miles downstream from Lower Three Runs Creek at Highway 301	.6	ND	ND	13	ND	6

[a] AEC radiation protection standard, 10 pCi/liter; sensitivity of analysis, 0.2 pCi/liter.

[b] AEC radiation protection standard, 3 nCi/liter; sensitivity of analysis, 4.0 pCi/liter.

ND, nondetectable, less than sensitivity of analysis.

up a sample of water and deposits it into a trough. The sampled water flows by gravity from the trough through connecting tubing into a large polyethylene jug which trails the sampler. The sampled water (up to 6 gallons) is collected weekly at river locations above and below SRP. Increased analytical sensitivity for water samples (containing insufficient radioactivity for direct processing) is achieved through concentration of radionuclides by ion exchange. The ion exchange column is counted directly for gamma-counting radionuclides.

Tritium, and trace amounts of cesium-137, strontium-89, and strontium-90 are the only radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout are also detected in river water upstream from SRP effluents. Average concentrations of all radionuclides found in river water during 1971, as shown in table 10, are only small fractions of the AEC standards.

Drinking water

Communities near SRP get drinking water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected in April and October. Data fom analyses of all public water samples from the immediate vicinity of the plant are in table 11.

The Beaufort-Jasper Water Authority operates a treatment facility to furnish drinking water, partially obtained from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. A water treatment plant at Port Wentworth, Ga. supplies water to a business-industrial complex near Savannah, Ga. These two water supplies are analyzed monthly for tritium content.

There is no evidence that SRP contributes radioactivity to drinking water supplies of any of the 14 surrounding towns; concentrations of alpha activity (1.2 pCi/liter) and beta activity

Table 10. Average concentration of radionuclides in Savannah River water, January-December 1971

Radionuclide	Concentration (pCi/liter)			Percent AEC standard at Highway 301
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	
Tritium	300	570	5 550	0.19
Sulfur-35	5.0	ND	ND	<.01
Chromium-51	4.3	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Cobalt-60	1.4	ND	ND	<.005
Zinc-65	1.1	ND	ND	<.001
Strontium-89	.3	ND	.7	.02
Strontium-90	.01	.6	.9	.30
Zirconium-niobium-95	.5	ND	ND	<.001
Ruthenium-103, 106	3.2	ND	ND	<.03
Iodine-131	.2	ND	ND	<.07
Cesium-134, 137	<.01	ND	.16	.001
Barium-lanthanum-140	1.6	ND	ND	<.01
Cerium-141, 144	2.5	ND	ND	<.02
Neptunium-239	2.2	ND	ND	<.002

ND, nondetectable, less than sensitivity of analysis.

Table 11. Radioactivity in drinking water, January-December 1971

Sampling points	Source of water	Alpha radioactivity[a] (pCi/liter)		Nonvolatile beta radioactivity[b] (pCi/liter)		Tritium[c] (pCi/liter)	
		April	October	April	October	April	October
Aiken	Stream, well	2.7	0.7	6	10	750	520
Allendale	Deep well	ND	.5	ND	9	ND	ND
Augusta	River	.8	ND	ND	6	650	ND
Barnwell	Deep well	.5	ND	ND	7	ND	ND
Bath	Lake	1.8	ND	6	ND	ND	ND
Blackville	Deep well	.5	.3	ND	ND	ND	ND
Clearwater	Lake	.7	.3	ND	ND	650	850
Jackson	Deep well	8.2	5.9	18	15	ND	ND
Langley	Stream	3.6	2.0	7	10	480	ND
New Ellenton	Deep well	1.3	1.0	ND	6	ND	ND
North Augusta	River	.4	ND	ND	7	500	ND
Sardis	Deep well	ND	ND	4	6	ND	ND
Waynesboro	Stream	ND	ND	8	6	580	ND
Williston	Deep well	2.2	.8	4	9	ND	ND
Average[d]		1.6	0.9	6	7		

[a] AEC radiation protection standard, 30 pCi/liter; sensitivity of analysis, 0.2 pCi/liter.
[b] AEC radiation protection standard, 3 nCi/liter; sensitivity of analysis, 4.0 pCi/liter.
[c] AEC radiation protection standard, 3 μCi/liter; sensitivity of analysis, 300 pCi/liter.
[d] Averages are calculated using sensitivity values for those individual items that were less than the sensitivity of their analysis.
ND, nondetectable, less than sensitivity of analysis.

(7 pCi/liter) are essentially the same as those observed before plant startup. The higher than average alpha activity (7.0 pCi/liter) at Jackson is attributed to naturally occurring radioactivity, primarily thorium-228 and its short-lived daughter products. Very low levels of tritium are found in drinking water of several of the towns that use surface water (maximum of 750 pCi/liter). Concentrations of tritium in water from deep wells are less than the sensitivity of the analyses (300 pCi/liter).

Milk

Milk is sampled at four dairies within a 25-mile radius of SRP, as shown in figure 2. Samples are collected biweekly and analyzed for tritium and radioiodine. Analyses are made quarterly for strontium-90 and monthly for cesium-137. Milk produced in the area and sold by major distributors is also analyzed for these radionuclides. Results from analyzing milk for radioactivity during 1971 are summarized in table 12.

Strontium-90 and cesium-137 in milk are attributed to fallout. Average concentrations of the radionuclides in milk were 10 pCi/liter of strontium-90 and 15 pCi/liter of cesium-137. Iodine-131 in milk samples was less than the sensitivity of the analysis (1 pCi/liter) throughout the report period. The strontium, cesium, and iodine values—which are consistent with

Table 12. Radioactivity in milk from local dairies, Savannah River Plant, January-December 1971

Local dairies	Concentration (pCi/liter)								
	Tritium[a]			Strontium-90[b]			Cesium-137[c]		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Aiken	960	ND	425	16	7	10	20	4	12
North Augusta	4 700	ND	1 125	26	15	19	30	4	17
Waynesboro	2 000	ND	800	8	5	6	20	4	12
Barnwell	5 500	ND	2 300	12	10	11	26	9	17
Major distributors[d]	1 500	ND	680	11	8	9	27	1	15

[a] AEC radiation protection standard, 3 μCi/liter; sensitivity of analysis, 300 pCi/liter.
[b] AEC radiation protection standard, 300 pCi/liter; sensitivity of analysis, 1.0 pCi/liter.
[c] AEC radiation protection standard, 20 nCi/liter; sensitivity of analysis, 1 pCi/liter.
[d] Milk produced in local dairies but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

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those reported by the U.S. Public Health Service for most sections of the United States (*1*)—represent 3.3, 0.07, and 0.3 percent of the respective AEC standards for water. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1 300 pCi/liter) is 0.04 percent of the AEC standard for water.

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass is selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples are routinely collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route. Samples from each quadrant of the plant and of the surrounding area are composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) are from weapons tests fallout. Alpha emitters averaged 0.15 pCi/g at the plant perimeter and at the 25-mile radius locations, the same as during 1970; gamma emitters averaged 24 pCi/g as compared to 15 pCi/g for 1970. Radioisotopic concentrations found in grass samples are presented in table 13.

Farm produce

Sixty samples of farm produce representing four food categories (grain, fruit, poultry, and leafy vegetables) are collected at 14 locations in the 6 counties surrounding SRP during the summer and fall of each year. Two samples of local beef were also collected from Waynesboro, Ga. All samples were analyzed by gamma spectrometry for cerium-144, iodine-131, ruthenium-103, ruthenium-106, cesium-137, and manganese-54. Radiochemical analyses are used for strontium-90 and alpha emitters (uranium and plutonium), and liquid scintillation counting for tritium. With exception of grains, all

Table 13. Radioactivity in vegetation, January-December 1971

Sampling points	Concentration (pCi/g dry weight)											
	Alpha emitters [a]		^{137}Cs [b]		^{141,144}Ce [c]		^{103,106}Ru [d]		^{95}Zr-Nb [e]		^{7}Be [f]	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Plant perimeter (7 locations)	1.1	0.15	3.8	1.4	27.5	7.7	4.4	1.6	11.0	2.8	35.5	10.4
25-mile radius (7 locations)	.7	.15	1.1	.7	14.1	6.4	5.0	2.2	5.2	2.5	23.1	11.0

[a] Sensitivity of analysis, 0.10 pCi/liter.
[b] Sensitivity of analysis, 0.3 pCi/liter.
[c] Sensitivity of analysis, 1.0 pCi/liter.
[d] Sensitivity of analysis, 1.4 pCi/liter.
[e] Sensitivity of analysis, 0.5 pCi/liter.
[f] Sensitivity of analysis, 3.0 pCi/liter. A natural radionuclide.

Table 14. Radioactivity in agricultural products, January-December 1971

Media	Number of samples	Concentration (pCi/g wet weight)										Tritium [f] (nCi/liter)	
		^{90}Sr [a]		^{141,144}Ce [b]		^{95}Zr-Nb [c]		^{137}Cs [d]		Alpha emitters [e]			
		Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Collards	14	0.50	0.30	ND	ND	ND	ND	0.10	0.03	0.024	0.004	30	7.6
Plums	14	.16	.05	0.22	ND	ND	ND	ND	ND	.004	.002	9	4.1
Oats, rye, and wheat	14	.25	.12	.22	ND	0.18	ND	.10	.05	.006	ND	26	4.9
Corn	14	.07	.03	ND	ND	ND	ND	.12	.06	.002	ND	9	4.5
Chicken	4	.10	.07	ND	ND	ND	ND	ND	ND	.005	.002	5	3.8
Beef	2	NA	NA	NA	NA	NA	NA	.04	.04	NA	NA	1	1.4

[a] Sensitivity of analysis, 0.02 pCi/liter.
[b] Sensitivity of analysis, 0.06 pCi/liter.
[c] Sensitivity of analysis, 0.02 pCi/liter.
[d] Sensitivity of analysis, 0.02 pCi/liter.
[e] Sensitivity of analysis, 0.002 pCi/liter.
[f] Sensitivity of analysis, 1.0 pCi/liter. Concentration in free water.
ND, nondetectable, less than sensitivity of analysis.
NA, no analysis.

foods are prepared for analysis in a manner similar to that used to prepare them for human consumption. Peelings, seeds, and other nonedible parts are removed. Wheat containing the whole grains only, and oats containing both grains and husks, are processed unwashed. Results are summarized in table 14. Concentrations in some samples are too low for reliable measurement, and only the results above the detection limit of the analyses are included.

SRP contributions to the levels of radioactivity (excluding tritium) in farm produce were so low in 1971 that they were indistinguishable from fallout. All radionuclides in food are near or below the levels of detection. Results of strontium-90 are about the same as in the 1970 samples with the highest concentration again in collards (0.5 pCi/g). Tritium concentrations in foods are similar to those found in rain water, with maximum value (30 nCi/liter) in samples collected near the plant perimeter.

Fish

Fish traps are maintained in the Savannah River, upstream, adjacent to, and downstream from the SRP effluents. Individual whole fish are analyzed by gamma spectroscopy for cesium-137 and other gamma emitting radionuclides; bone from each specimen is composited monthly for strontium-89 and strontium-90. Fish analysis data are presented in table 15.

The radioactivity in bone and flesh of fish shows some measurable contribution by SRP, but concentrations are of minor significance from a radiation dose viewpoint. An adult regularly consuming fish from the river adjacent to SRP (at a rate of 25 pounds/year) would receive a whole-body dose of only 2.7 mrem as compared to approximately 125 mrem from natural radiation.

Deer

Concentrations of cesium-137 in 865 deer and 8 hogs killed during the autumn 1971 hunt were estimated with a portable, single-channel scintillation instrument before release of the animals to the hunters. The estimated cesium-137 content was verified by gamma spectroscopic analysis of muscle tissue of 135 deer. Deer and hog analysis data are shown in table 16.

Cesium-137 concentrations in deer are well within the range of concentrations found in deer killed in similar terrain through the southeast. The cesium presumably originated almost entirely from that deposited by fallout from nuclear weapons tests. The average cesium-137 concentration in deer was 11 pCi/g with a maximum of 48 pCi/g. Edible meat from the deer containing 48 pCi/g would weigh about 40 pounds and would therefore contain about 0.87 Ci of cesium-137. An adult eating all of this deer meat would receive a radiation dose of 50 mrem to the whole body, 40 percent of the annual dose South Carolina residents receive

Table 15. Radioactivity in Savannah River fish, January-December 1971

Location	Number of fish assayed		Type of sample	Concentration (pCi/g wet weight)					
				Cesium-137				Strontium-89, -90	
	Bream [a]	Catfish [b]		Bream [a]		Catfish [b]		Bream and catfish	
				Maximum	Average	Maximum	Average	Maximum	Average
Above SRP boundary	59	115	Bone	NA	NA	NA	NA	23	10
			Flesh	25	2.2	15	2.0	NA	NA
Adjacent to SRP	23	55	Bone	NA	NA	NA	NA	21	11
			Flesh	18	4.2	21	4.0	NA	NA
Below SRP at Highway 301	175	63	Bone	NA	NA	NA	NA	14	8
			Flesh	20	2.6	11	2.9	NA	NA

[a] Shellcracker, bluegill, and redbreast (*Lepomis*).
[b] Predominantly yellow cat (*Ictalurus*).
NA, no analysis.

Table 16. Radioactivity in deer and hogs January-December 1971

Number of animals	Species	Cesium-137 in flesh (pCi/g wet weight)	
		Average	Range
865	Deer	11	<1–48
8	Hogs	10	6–19

from natural radiation (*2*). Radiozinc (zinc-65) is the only other gamma-emitting radionuclide detected in deer tissue; a maximum of 6 pCi/g was found in one of three deer showing zinc-65.

Summary

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1200-square mile area outside the Savannah River Plant. Included are parts of Aiken, Barnwell, and Allendale counties in South Carolina; and Richmond, Burke, and Screven counties in Georgia. Although very small amounts of gaseous and liquid radioactive materials are discharged to the environment, environmental levels continue to be far below levels considered significant from a public health viewpoint.

The quantity of radioactivity released by SRP to its environs during 1971 is, for the most part, too small to be distinguished from natural background radiation and fallout from worldwide nuclear weapons tests. Particulate beta radioactivity detectable in air is due entirely to global fallout. This concentration in air at the plant perimeter and 25 miles away represents 0.2 percent of the AEC standard. Tritium oxide in air at the plant perimeter is greater than in air at more distant locations. The average concentration at the plant perimeter, only 0.1 percent of the AEC standard, is the largest percentage of any AEC air standard for plant-released radionuclides.

Tritium, cesium-137, strontium-89, and strontium-90 are the only radionuclides of plant origin detectable in river water. None of these had an average concentration that exceeded 0.2 percent of the AEC standard in river water sampled 8 miles downstream from the plant. Radioactive materials in river fish also continue to be very low. Various water quality analyses of river water samples surveyed by SRP indicate that Savannah River water is not adversely affected by SRP operations. This is substantiated by surveys of the health of the Savannah River biota by the Academy of Natural Sciences of Philadelphia.

REFERENCES

(*1*) ENVIRONMENTAL PROTECTION AGENCY. Radiation Data and Reports (monthly publication). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) ENVIRONMENTAL PROTECTION AGENCY. Background levels by States. Fuel News, Vol. 15, No. 1 (January 1972).

Previous coverage in *Radiation Data and Reports*:

Period	Issue
January-June 1971	March 1972

Reported Nuclear Detonations, January 1974

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on January 30, 1974. The signals originated at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20-200 kilotons.

There were no reported nuclear detonations for the United States for January 1974.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A RADIOACTIVE ISOTOPE CHARACTERIZATION OF THE ENVIRONMENT NEAR WISCASSET, MAINE; A PREOPERATIONAL SURVEY IN THE VICINITY OF THE MAINE YANKEE NUCLEAR REACTOR. *Dr. C. T. Hess, Dr. C. W. Smith, H. A. Kelley, and F. C. Rock. Radiation Data and Reports. Vol. 15,* February 1974, pp. 39–52.

An environmental radioactivity survey was conducted in the vicinity of the Maine Yankee Nuclear Power Station prior to the operation of this facility. Measurements of environmental radioactivity were made on samples of soil, sediment, well water, surface water, estuarine water, air particulates, air moisture, and precipitation.

Natural radioisotopes in the uranium and thorium series and potassium-40 were found in most of the samples. Cesium-137 also was found in some samples.

KEYWORDS: Air, environmental survey, Maine, reactor environs, sediment, soil, water.

RADIATION DATA AND REPORTS

Volume 15, Number 3, March 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
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U.S. ENVIRONMENTAL PROTECTION AGENCY
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Reports

Radiological Surveillance Around Turkey Point, 1970–1971

Wallace Johnson and Jearold Eakins[1]

Prior to the operation of the Turkey Point Nuclear Power reactor, environmental media were sampled and data are presented for 1970–1971. Basic media investigated include air, precipitation, soil, silt, and water, including sea water.

A number of media utilized as indicator organisms serve to investigate the behavior of radionuclides in several ecological levels. Indicators are mangrove vegetation, fresh water algae, turtle grass and sponges. Additional items found in the human food chain that were analyzed include crustacea, fish, and food crops.

The Florida Division of Health has conducted radiological surveillance around the Turkey Point site of Florida Power and Light Company since August 1969. Sampling is conducted by the Radiological and Occupational Health Section.

Turkey Point Nuclear Units 3 and 4 are located on the western shore of Biscayne Bay about 25 miles south of Miami, Florida. The site consists of 3300 acres of which the plant, including two operating fossil-fueled units, occupies about 150 acres of compacted limestone fill. East of the site, 5 to 8 miles across Biscayne Bay, is a series of islands running in a northeast-southwest direction between the bay and the Atlantic Ocean.

To the north and west of the site, land use is primarily agricultural to a distance of about 7 miles where urban development begins, becoming densely populated further north along the coast.

The southern coastland consists of uninhabited mangrove swampland extending inland from 1 to 3 miles. Dade County's Homestead Bayfront Park begins immediately north of the plant site and a Hawk Missile Base adjoins the site near the northwest corner.

Samples are obtained from the sampling locations shown in figures 1 and 2. The samples are analyzed in the Radiological Laboratory of the Division of Health in Orlando. Gamma analysis data were obtained using 10 cm × 10 cm NaI detectors based on a 9 × 9 matrix resolution of spectra calculated by the simultaneous equation method. Beta determinations are made using a Sharp Lo Beta counting system or a Nuclear Chicago low background proportional counter, model 4334. Low energy beta samples are counted on a Packard Tri-Carb Liquid Scintillation Spectrometer, Model 3375.

An internal quality control program is conducted to define the precision of analyses. Twenty percent of the samples are divided and analyzed in two parts. These samples are not identified to laboratory personnel until the end of the quarter. This parameter defines the analytical variability between sample analyses.

For example, based on this parameter, the following differences in samples would be required to define a significant difference.

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[1] Radiological and Occupational Health Section, Bureau of Preventable Diseases, Division of Health, Department of Health and Rehabilitative Services, Jacksonville, Fla. 32201.

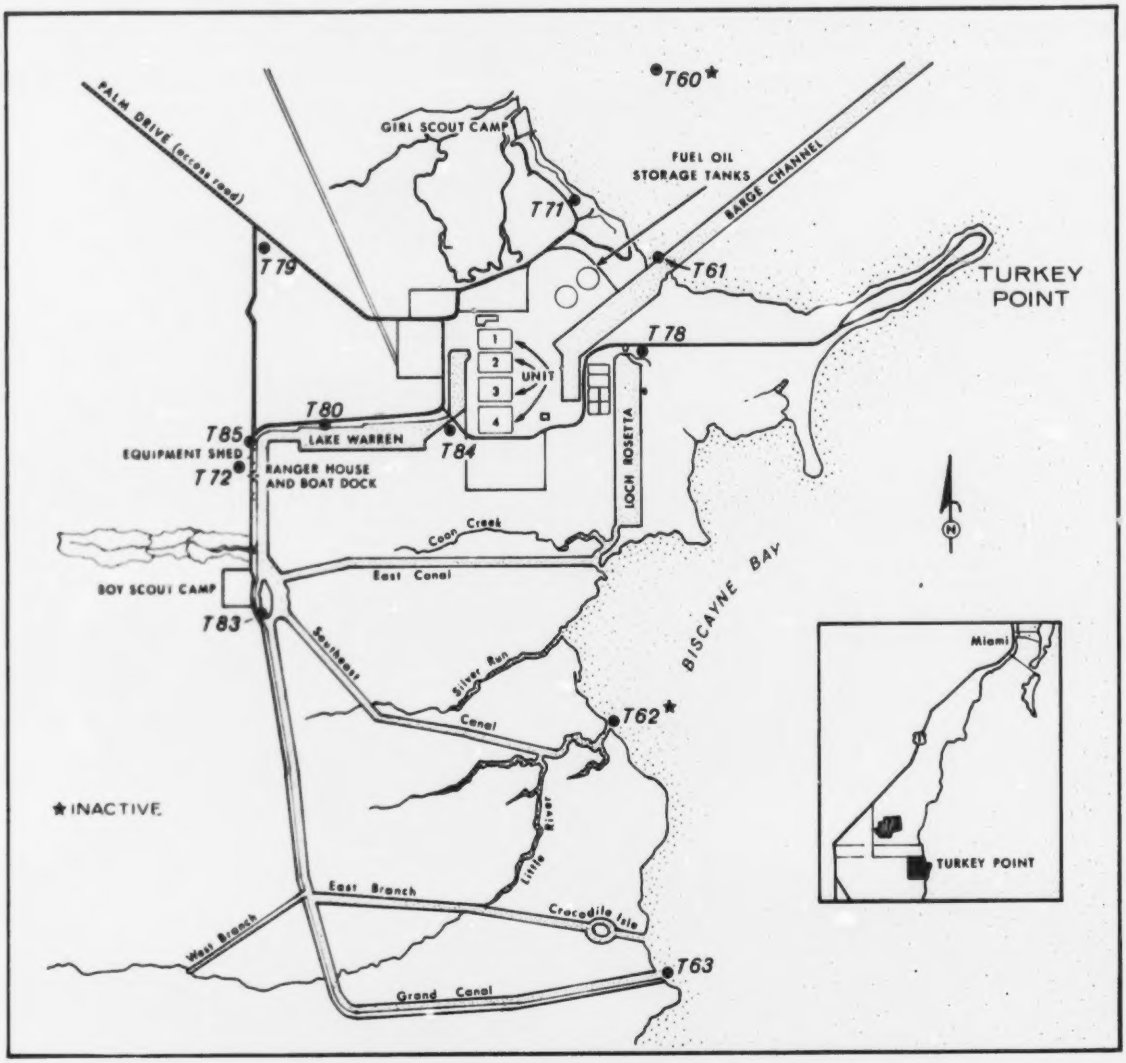

Figure 1. Onsite sampling locations, Turkey Point plant area

Silt and soil samples (see table 1)

Gamma analysis	Significant difference
Cerium-144	358 pCi/kg wet weight
Ruthenium-106	223 pCi/kg wet weight
Cesium-137	148 pCi/kg wet weight
Zirconium-95	108 pCi/kg wet weight
Gross beta (including potassium-40)	3.1 pCi/g ash 1 822 pCi/kg wet weight

The parameter, however, is defined only for those radionuclides which have been consistently present in quantities greater than the practical reporting limit.

External quality control to estimate the accuracy of analyses has been conducted using split samples and interlaboratory comparisons. A summary of 1971 quality control results are shown in table 2.

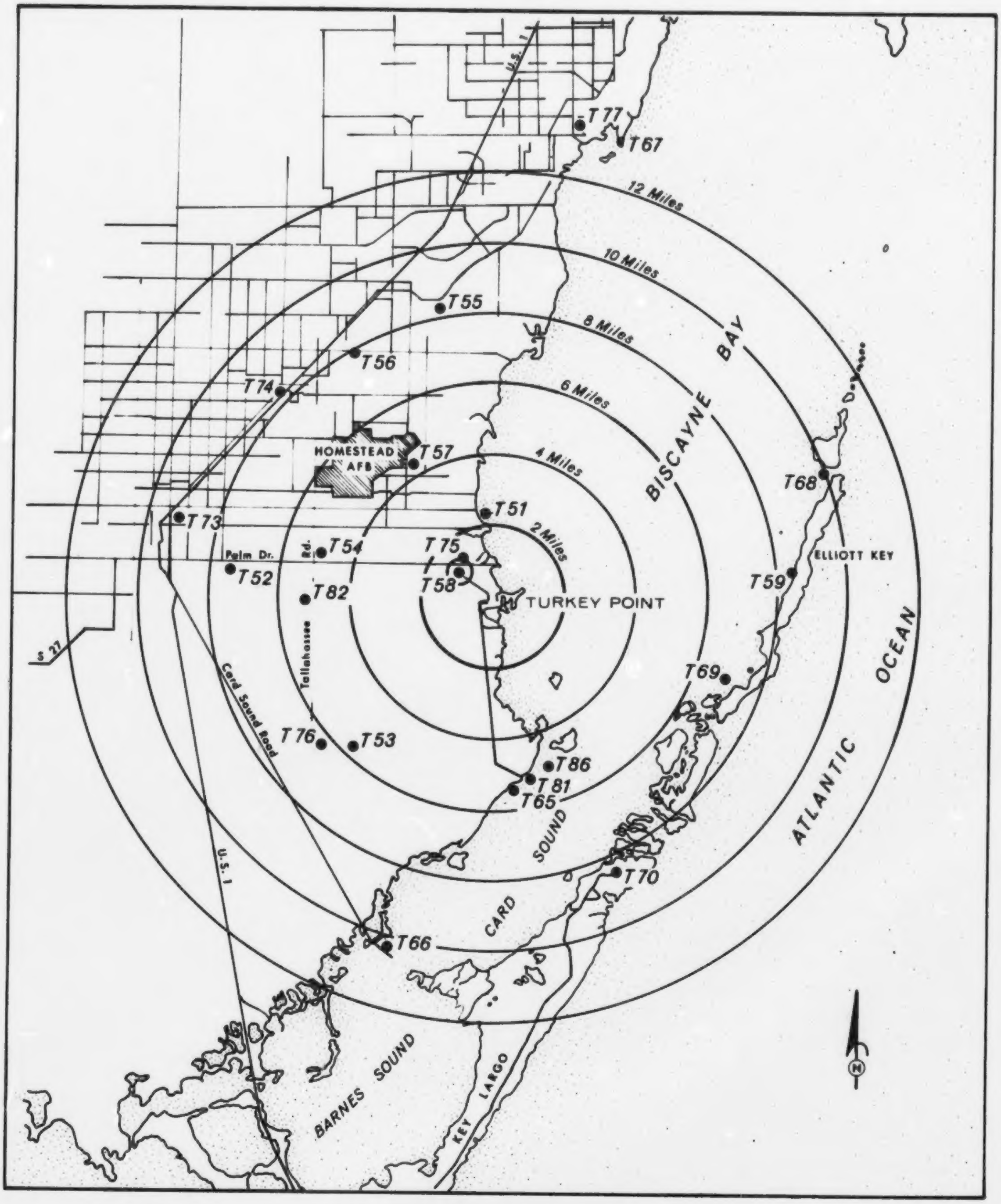

Figure 2. Offsite sampling survey stations, Turkey Point

Table 1. Results of the quality control sample analysis, 1971

Type of analysis	Soil			Vegetation			Water, UDS[a]			Water, DS[b]		
	n	$\overline{X}$	σ	n	$\overline{X}$	σ	n	$\overline{X}$	σ	n	$\overline{X}$	σ
Gamma:												
(pCi/g wet weight)												
Cerium-144	28	166	192									
Ruthenium-106	11	94	129	15	148	105						
Cesium-137	21	71	77	28	108	167						
Zirconium-95	21	48	60	27	117	134						
Potassium-40	6	35	47	38	452	492				29	43	30
Gross beta: [c]												
(pCi/g wet weight)	36	1.5	1.6	38	17	16						
(pCi/kg wet weight or liter)	36	885	937	38	354	388	42	0.7	2.9	42	48	62
Weight:												
(g wet)	36	27	30	38	2	2	42	74	416	42	0.5	0.6

[a] Undissolved solids.
[b] Dissolved solids.
[c] Includes potassium-40.

Table 2. Summary of radiological laboratory's 1971 quality control cross-checks

Type of analysis	Average percent relative error	Number of cross-check samples
Gamma:		
Iodine-131	+1. 2	6
Barium-140	+12.9	1
Cesium-137	− 7.7	10
Ruthenium-106	+ 4.2	1
Cobalt-60	− 4.2	2
Potassium-40	+ 2.9	7
Gross beta [a]	−31.3	3
Specific radionuclide analysis:		
Strontium-90	+ 8.0	10
Tritium	− .3	3

[a] Includes potassium-40.

Table 3. Practical reporting limits

Radionuclide	Concentration (pCi/liter)			
	Vegetation	Water	Soil	Biota
	3.5 liter geometry	3.5 liter geometry	1.0 liter geometry	1.0 liter geometry
Cerium-144	97	97	200	200
Iodine-131	17	17	40	40
Ruthenium-106	83	83	180	180
Cesium-137	17	17	40	40
Zirconium-95	14	14	30	30
Manganese-54	14	14	30	30
Zinc-65	31	31	70	70
Potassium-40	180	51	390	390
Barium-140	17	17	40	40

Strontium-90	0.08	pCi/g ash
Tritium	200	pCi/liter
Cobalt-60	40	pCi/liter (separation)
Iron-55	0.125	pCi/g ash

Gross beta[a] — water:	
Dissolved solids	3 pCi/liter
Undissolved solids	3 pCi/liter
Gross beta[a] — ash	10 pCi/g ash

[a] Includes potassium-40.

Practical reporting limits used in this program are shown in table 3. For purposes of this report, activities below the practical reporting limit (PRL) are shown as < PRL.

One purpose of preoperational radiological surveillance around nuclear-powered electric generating facilities is to establish the radiation characteristics of the environs prior to startup of the reactor. For this purpose, the preoperational radionuclide levels in a number of media and background radiation levels should be established. The media include soil, silt, and water.

Data on soil analyses for commonly detected nuclides are shown in table 4 for 1970 and in table 5 for 1971. Soil samples are collected semiannually.

Data on analysis of radioactivity in silt is shown in table 6 for 1970 and in table 7 for 1971. Silt samples are collected quarterly.

Gamma background radiation data normalized to μrem/h for 1971 are presented in table 8. These measurements are made using CaF:Mn glass envelope thermoluminescent dosimeters (Victoreen Model 2600–17) with readout on a Victoreen Model 2600 B thermoluminescent dosimeter reader. The dosimeters are calibrated

Table 4. Soil, 1970

Sampling location	Radionuclide (annual average pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Cesium-137
T51	<390	1 062	<291	<155	522
T52	<390	<685	<220	<72	492
T53	<390	[a] 3 200	[a] 1 500	[a] 490	[a] 950
T54	<390	632	<180	<57	180
T55	<390	830	<180	<50	347
T56	<390	<812	<180	<37	320
T57	<390	910	<275	<132	305
T58	<390	912	<327	<205	100
T59	<390	<543	<247	87	285
T72	<497	<467	<180	<33	<63
Grand mean	<401	<1 005	<358	<132	<356
Control:					
T64	<390	447	<267	<95	<55

[a] Only one observation.

Table 5. Soil, 1971

Sampling location	Radionuclide (annual average pCi/kg wet weight)					
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	<390	<575	<290	<200	—	<170
T52	<390	575	<185	80	—	475
T53	<395	2 100	1 025	440	11 000	570
T54	<565	910	<180	<100	—	475
T55	<390	<525	<180	<70	—	395
T56	<945	<200	<180	<90	14 000	<170
T57	<390	<415	<180	<60	—	315
T58	<390	<850	<585	<365	—	<85
T59	<390	[b] 740	[b] 350	[b] 120	—	[b] 360
T72	<390	<205	<180	<55	—	<40
Grand mean	<464	<710	<334	<158	12 500	<254
Control:						
T64	<412	<562	<245	<140	—	<355

[a] Includes potassium–40.
[b] Only one observation.

Table 6. Silt, 1970

Sampling location	Radionuclide (annual average pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Cesium-137
T51	<390	<310	<180	<37	<40
T60	<555	<490	<180	<30	<40
T61	<390	<400	<180	<30	<40
T63	<503	767	<183	<53	<60
T64	NA	NA	NA	NA	NA
T65	<390	<305	<180	<30	<40
T66	<390	<235	<180	<30	<40
T71	<407	<550	<180	87	<40
T72	<407	<220	<180	<30	<40
T75	<417	380	<180	70	<40
T76	<390	<312	<180	<30	<122
Grand mean	<424	<397	<180	<43	<50

NA, no analyses.

Table 7. Silt, 1971

Sampling location	Radionuclide (annual average pCi/kg wet weight)					
	Potassium-40	Cerium -144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	<390	487	<257	<150	2 100	<40
T60	487	580	<180	<30	2 680	<42
T61	500	<487	<180	<37	3 050	<40
T63	<472	<437	<180	<35	3 150	<40
T65	<390	<322	<180	<30	ND	<40
T66	<472	355	<180	<32	ND	<40
T71	<390	587	<180	<33	ND	<40
T72	<402	<200	<180	<30	ND	<40
T75	<390	<452	<200	<70	2 900	<40
T76	<390	898	<294	<130	7 370	<174
T80	<390	630	<215	<85	[b] 2 600	<40
T83	<390	<367	<183	100	[b] 2 000	<40
Grand mean	<422	<484	<201	<64	<3 230	<51
Control:						
T64	<390	<233	<180	<40	ND	<40

[a] Includes potassium-40.
[b] One observation. Other three nondetectable.
ND, nondetectable.

Table 8. Gamma background levels, 1971

Sampling location	Dose rate (μrem/h)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
T51	NA	NA	NA	NA	NA	NA	NA	20	20	18	18	18	18
T52	17	17	19	21	19	18	18	18	18	20	18	20	19
T56	18	NA	20	22	20	20	19	21	19	18	15	19	19
T57	17	17	19	20	19	19	18	18	18	20	14	17	18
T58	22	17	21	20	20	18	19	18	19	20	18	21	19
T64	14	19	17	20	18	20	16	19	NA	19	17	19	18
T70	NA	14	20	15	21	15	16	21	20	17	16	20	18
T71	15	17	16	18	16	17	15	17	16	18	17	18	17
T72	16	16	18	18	18	16	17	16	17	16	18	17	17
T78	NA	17	18	18	17	17	16	17	17	17	16	17	17
T79	NA	19	15	20	14	18	13	18	15	17	15	17	16
Mean	17	17	18	19	18	18	17	18	18	18	16	18	

NA, no analysis.

against a cobalt-60 source using a Victoreen R chamber as a secondary standard. Since the objective of this sampling is to establish baseline values from which to measure changes, no attempt has been made to determine absolute environmental backgrounds. Correction has not been made for the inherent drift of the dosimeter; hence, the values reported are for gross dosimeter response. The mean values of reported dosimeter drift have been determined to range from 6.78 μrem/h to 10.79 μrem/h with an average value of 8 μrem/h.

The standard deviation of measurements within monthly groups can be calculated to be 2 μrem/h while the standard deviation between monthly groups can be calculated to be 3 μrem/h. Based on these values, a change of x ± 4 μrem/h between stations or x ± 6 μrem/h between months would be significant at the 95 percent confidence level. A two-way analysis of variance performed on the data indicates that differences in means of monthly observations are significant at the 95-percent confidence level.

Monthly values for 1970 dosimeters are listed in table 9. Sites T70, T78, and T79 were not equipped with TLD's until February 1971. Site T51 was started in August 1971.

Table 9. Gamma background levels, 1970

Sampling location	Dose rate (μrem/h)				
	Aug	Sept	Oct	Nov	Dec
T52	15	14	13	15	15
T56	16	15	15	15	18
T58	14	12	13	12	15
T64	15	13	14	14	16
T71	14	12	13	13	15
T57	15	13	14	15	16
T72	13	14	12	14	12
Mean	15	13	13	14	15

Table 11. Analysis of seawater, 1971

Sampling location	Annual average concentration (pCi/liter)				
	Potassium–40	Cobalt–58	Cobalt–60	Tritium	Gross beta [a]
T51	327	<40	<40	<200	438
T60	344	<40	<40	<200	448
T61	348	<40	<40	<200	461
T63	347	<40	<40	<200	459
T65	347	<40	<40	<200	430
T66	393	<40	<40	<200	524
T67	376	<40	<40	<200	427
T71	340	<40	<40	<200	508
T72	356	<40	<40	<200	481
Mean	353	<40	<40	<200	464

[a] Includes potassium–40.

Sampling for particulates in air is conducted using a low-volume (1 cfm) sampler operated continuously. Particulates are collected on 2-inch vinyl metricel filters (Gelman VM–1). The filters are collected biweekly and analyzed for gross beta. During this reporting period, all results have been less than 1 pCi/m^3. This value is used as the practical reporting level in this laboratory.

Monthly composites of these filters have been analyzed by gamma spectroscopy and results for 1970 are shown in table 10. No gamma results are available for 1971.

Table 10. Turkey Point gamma scan particulates in air, 1970[a]

Radionuclide	January (pCi/sample)	February (pCi/sample)	March (pCi/sample)	April (pCi/sample)	May (pCi/sample)	June (pCi/sample)
Cerium-praseodymium-144	ND	ND	ND	310	290	390
Iodine-131	ND	ND	ND	ND	ND	ND
Ruthenium-rhodium-106	ND	ND	ND	ND	ND	ND
Cesium-137	ND	ND	ND	ND	ND	ND
Zirconium-niobium-95	ND	ND	ND	50	60	100
Manganese-54	ND	ND	ND	ND	ND	ND
Zinc-65	ND	ND	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND	ND	ND
Sample volume (m^3)	2 630	3 543	6 472	5 718	4 775	7 266
	July (pCi/sample)	August (pCi/sample)	September (pCi/sample)	October (pCi/sample)	November (pCi/sample)	December (pCi/sample)
Cerium-praseodymium-144	260	ND	ND	ND	290	230
Iodine-131	ND	ND	ND	ND	ND	ND
Ruthenium-rhodium-106	ND	ND	ND	ND	280	470
Cesium-137	ND	ND	ND	ND	ND	ND
Zirconium-niobium-95	50	30	30	30	100	110
Manganese-54	ND	ND	ND	ND	ND	ND
Zinc-65	ND	ND	ND	ND	ND	ND
Potassium-40	ND	ND	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND	ND	ND
Sample volume (m^3)	5 046	3 187	3 798	6 099	6 184	6 879

[a] All site samples composited by month of collection and dissolved in 1.0 liter of nitric acid. Detectable levels are: cerium-praseodymium-144 200 pCi; iodine-131, 40 pCi; ruthenium-rhodium-106, 180 pCi; cesium-137, 40 pCi; zirconium-nobium-95, 30 pCi; manganese-54, 30 pCi; zinc-65, 70 pCi; potassium-40, 180 pCi; and barium-lanthanum-140, 40 pCi.
ND, nondetectable.

Analysis of seawater and of precipitation are shown in tables 11 and 12. Results of well water analyses are not shown since all results have been less than the practical reporting limits. Seawater collection frequency is monthly. Precipitation is also collected monthly, but actual quantity collected depends on monthly rainfall. In order to obtain a sample, at least 3.5 liters must have been collected in the sampler during the previous month.

The foregoing data represent the basic environmental media and serve to demonstrate radionuclides present in detectable amounts.

The remainder of the data serves to investigate the behavior of these radionuclides in several ecological levels. The first such groups

Table 12. Analysis of precipitation, 1971

Sampling location	Radionuclide concentration (pCi/liter)			
	Cobalt–58	Cobalt–60	Tritium	Gross beta [a]
T64	<40	<40	<200	11
T79	<40	<40	<200	8

[a] Includes potassium–40.

include a number of media utilized as indicator organisms. These items may, or may not, be a part of a food chain pathway. One such indicator is the mangrove (*Rhizophora* mangle). Mangroves are one of the most important elements in the ecology of tropical and subtropical areas. Energy flow, or the movement of nutrients from the land to the estuary, is the basic key to many of the lower food webs, since decomposition of the organic matter produced by the mangrove results in great quantities of food for plant and animal plankton.[2]

Analysis of mangrove vegetation (leaves) for 1970 is shown in table 13 and for 1971 in table 14. Mangrove samples are collected on a quarterly basis.

The fresh water alga, *Chara*, was chosen as another indicator of radionuclide reconcentration. *Chara* is found usually in alkaline or hard water streams where calcium is abundant in the form of carbonates or bicarbonates. Marl and other kinds of calcareous deposits may be formed largely by *Chara* over long periods of time (*1*).

Table 13. Mangrove vegetation, 1970

Sampling location	Annual average concentration (pCi/kg wet weight)				
	Potassium–40	Cerium–144	Ruthenium–106	Zirconium–95	Cesium–137
T51	3 080	<285	<478	345	< 55
T53	2 150	<240	<280	140	105
T58	2 580	<259	<333	<240	< 43
T59	5 930	<200	<333	233	<136
T64	2 700	<290	<457	307	< 45
Mean	3 290	255	376	253	77

Polikarpov (*2*) reports the mean concentration factor of 20 radionuclides in *Chara* to be 2 630. These radionuclides include zirconium–95, ruthenium–106, and cerium–144, which are among isotopes seen in our *Chara* samples.

Table 15 lists the *Chara* samples analyzed in 1970 and 1971 along with water samples taken at the same location. This could serve to demonstrate concentration factors, but all water samples showed less than PRL values. It should be realized that the concentration factor given by Polikarpov is in relation to dry weight, whereas our results are reported by kilogram of wet weight. *Chara* samples are collected on a quarterly basis.

Turtle grass (*Thalassia testudinum*) and *Sargassum* were chosen as representative marine algae because of their abundance in shallow bays of South Florida.

Turtle grass is of tremendous importance as a habitat and nursery ground for marine animals. It also furnishes food for many creatures and helps stabilize bay bottoms by holding the sediments in place. Based on samplings done by the Miami Institute of Marine Sciences,

Table 14. Mangrove vegetation, 1971

Sampling location	Annual average concentration (pCi/kg wet weight)					
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]	Cesium-137
T51	3 250	<200	<310	<200	3 150	<40
T53	1 600	<200	<382	172	2 480	<40
T58	3 350	<200	<347	195	3 720	<62
T59	3 230	<200	523	270	3 900	<73
Mean	3 670	<200	<390	<209	3 310	<54
Control: T64	[b] 2 800	<200	[b] 270	[b] 170	[b] 3 200	[b] <40

[a] Includes potassium–40.
[b] One observation.

---

[2] Draft detailed statement for Turkey Point, Units 3 and 4, by the Division of Radiological and Environmental Protection, U.S. Atomic Energy Commission, February 1972.

Table 15. Fresh water algae (*Chara*) and water samples, annual average means of detectable observations from Location T54

Radionuclide	1970		1971	
	Chara (pCi/kg wet weight)	Water (pCi/liter)	Chara (pCi/kg wet weight)	Water (pCi/liter)
Potassium-40	3 230	<51	<617	<51
Cerium-144	240	<97	<340	<97
Ruthenium-106	<180	<83	<280	<83
Zirconium-95	80	<14	<157	<14
Gross beta [a]		9	1 900	16

[a] Includes potassium-40.

Table 16. Turtle grass, 1971

Sampling location	Annual average concentration (pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]
T63	2 900	<340	<745	585	3 550
T66	4 770	<340	<290	227	4 800
Mean	3 830	<340	<517	406	4 170

[a] Includes potassium-40.

Table 17. *Sargassum*, 1971

Sampling locations	Annual average concentration (pCi/kg wet weight)				
	Potassium-40	Cerium-144	Ruthenium-106	Zirconium-95	Gross beta [a]
T51	6 180	<340	<290	380	6 080
T65	7 400	<340	<290	590	9 800
Mean	6 790	<340	<290	485	7 940

[a] Includes potassium-40.

it is estimated that 1-square mile of turtle grass will contain about 235 million shrimp and 95 billion mollusks. These animals serve as food for larger animals (*3*).

Sargassum is also an important plant, for it has its own ecological system. It provides shelter for many pelagic creatures, some of whom spend their entire life concealed in the seaweed. The particular species which we collect is floating and is never found attached (*3*).

Tables 16 and 17 give the results of radionuclide analysis on turtle grass and *Sargassum*, respectively. The only significant difference noted is the higher potassium-40 levels in *Sargassum*. Turtle grass and *Sargassum* are collected quarterly.

Sponges are perhaps the best indicator organism collected in the Turkey Point area. They consistently show higher levels of radionuclides than do other forms of marine life. This concentration is probably due to the fact that they are filter feeders and constantly draw water through their bodies, straining out minute organisms. Sponges are also easily collected. They are sessile benthic animals and thus do not migrate as do fishes and other marine organisms.

Table 18 lists the various radionuclides found in sponges collected and analyzed during 1970 and 1971. Sponge samples are collected quarterly.

Table 18. Sponge analysis, 1970-1971

Sampling location	1970					
	Concentration (pCi/kg wet weight)					
	^{144}Ce	^{106}Ru	^{137}Cs	^{95}Zr	^{40}K	Gross beta [a]
T59	3 500	1 200	<40	560	2 500	7 210
T63	1 200	1 000	<40	300	1 400	4 080
T68	2 200	1 300	<40	660	1 700	7 770
T69	1 500	1 700	<40	760	<390	10 200
	2 700	2 300	<40	610	1 600	5 950
Mean	2 200	1 500	<40	578	<1 520	7 030
	1971					
T68	1 800	700	<40	200	1 800	8 170
	7 400	<180	<40	90	1 800	15 200
Mean	4 600	<440	<40	145	1 800	11 700

[a] Includes potassium-40.

The remaining analyses constitute items found in the human food chain. Tables 19 and 20 give data for crustacea collected during 1970 and 1971. The most commonly sampled in

Table 19. Crustacea analysis, 1970 [a]

Sampling location	Type	Concentration (pCi/kg wet weight)				
		^{137}Cs	^{106}Ru	^{95}Zr	^{40}K	Gross beta [b]
T53	Blue crab	160	<180	<30	2 400	2 720
T54	Crayfish	110	200	50	2 400	1 440
T75	Lobster	150	<180	<30	1 500	1 480
Mean		140	<187	<37	2 100	1 880

[a] Entire organism is analyzed.
[b] Includes potassium-40.

Table 20. Crustacea analysis, 1971[a]

Sampling location	Type[a]	Concentration (pCi/kg wet weight)				
		^{137}Cs	^{106}Ru	^{95}Zr	^{40}K	Gross beta[b]
T61	Blue crab	<40	<180	<30	1 300	2 340
T65	Land crab	160	<180	<30	1 600	[c]5 110
T66	Blue crab	<40	<180	<30	1 200	2 430
	Blue crab	<40	<180	<30	1 400	3 080
Mean		<70	<180	<30	1 380	3 240

[a] Entire organism is analysed.
[b] Includes potassium-40.
[c] One detectable observation.

this group is the blue crab, *Callinectes sapidus*. Blue crabs are harvested commercially in the Biscayne Bay-Card Sound area. When available, crustacea are collected quarterly.

Tables 21 and 22 are analyses of fish collected at Turkey Point for the 2-year period. These fish are listed by common name except for those listed as unclassified. The unclassified samples were composed of more than one species of fish, usually a mixture of pinfish, small jacks and barracudas.

Table 21. Fish analysis, 1970[a]

Sampling location	Type	Concentration (pCi/kg wet weight)			
		^{137}Cs	^{40}K	Gross beta[b]	^{90}Sr
T58	Unclassified	260	1 800	2 320	159
T60	Barracuda	<40	3 700	1 420	NA
	Barracuda	<40	3 000	1 950	NA
T61	Jack	<40	2 800	1 680	NA
	Mangrove snapper	<40	2 800	1 760	NA
T62	Unclassified	60	2 700	1 570	NA
	Unclassified	50	3 200	1 720	5
	Unclassified	60	3 300	2 450	5
	Tarpon	<40	2 000	1 220	NA
	Jack	<40	2 800	1 900	NA
T63	Unclassified	50	2 500	2 340	16
	Mangrove snapper	<40	2 900	1 600	NA
	Weakfish	<40	2 400	1 620	NA
	Jack	<40	3 300	2 320	NA
T65	Unclassified	60	3 400	1 780	26
	Jack	40	1 800	2 010	NA
T66	Unclassified	60	3 000	2 480	28
	Unclassified	56	2 500	3 190	24
	Mullet	50	2 600	2 310	17
	Mullet	<40	1 800	1 870	NA
T68	Unclassified	<40	2 600	2 350	NA
T69	Unclassified	<40	2 700	2 690	NA
T75	Unclassified	240	1 400	1 820	88
T76	Unclassified	110	2 600	1 610	NA
	Unclassified	420	1 700	2 390	245
	Gar	290	1 600	1 720	NA
	Tarpon	100	1 300	982	NA
Mean		<88	2 500	1 970	61

[a] Entire organism is analyzed.
[b] Includes potassium-40.
NA, no analysis.

Table 22. Fish analysis, 1971[a]

Sampling location	Type	Concentration (pCi/kg wet weight)			
		^{137}Cs	^{40}K	Gross beta[b]	^{90}Sr
T62	Mangrove snapper	50	2 600	2 890	NA
	Mangrove snapper	<40	2 600	2 470	479
	Barracuda	<40	2 800	4 910	NA
	Unclassified	<40	3 600	4 370	NA
T63	Barracuda	<40	3 200	3 680	2.5
	Barracuda	100	2 300	3 480	NA
	Barracuda	<40	2 400	3 720	NA
	Barracuda	<40	2 500	4 600	NA
T65	Unclassified	70	2 500	2 040	3
	Snook	40	700	1 700	NA
	Jack	60	2 900	2 620	NA
T66	Mullet	<40	1 800	3 930	10.6
	Mullet	<40	1 600	4 000	NA
	Mullet	<40	1 800	3 050	21.8
	Mullet	40	2 500	3 210	NA
T68	Unclassified	<40	2 700	2 140	1
	Pin fish	<40	2 300	3 380	NA
T69	Unclassified	<40	2 600	2 000	18
	Unclassified	<40	2 300	4 380	NA
	Unclassified	<40	2 400	2 280	NA
Mean		<46	2 400	3 240	76.6

[a] Entire organism is analyzed.
[b] Includes potassium-40.
NA, no analysis.

Food crop analysis for 1970 and 1971 is compiled in table 23. Five locations are sampled on a monthly basis. These locations cover the principal farming areas in the northwest quadrant between 4 and 8 miles. However, due to climatic conditions, truck farming is practiced principally in the winter months, thus making sample collection difficult in the summer. In addition, crop rotation is practiced at most sites so that collection of a single crop at each site on every sampling is impossible. Sampling techniques involve collection of only the edible portions of the food crops at or about harvest time.

REFERENCES

(*1*) PRESCOTT, G. W. The fresh-water algae. William C. Brown & Co., Dubuque, Iowa (1964).

(*2*) POLIKARPOV, G. G. Radioecology of aquatic organisms (English translation). Reinhold Book Division, New York, N.Y. (1966).

(*3*) STEPHENS, W. M. Southern seashores. Holiday House, New York, N.Y. (1968).

Table 23. Analysis of food crops, 1970–1971

Sampling location	Food crop	Concentration (pCi/kg wet weight)		
		^{40}K	Gross beta [a]	^{90}Sr
1970:				
T52	Collard greens:	3 100	1 010	55
		3 200	2 020	53
		3 500	2 430	46
		2 800	836	20
		3 200	2 670	36
		4 100	2 450	58
		4 700	1 880	
	Mean	3 510	1 900	45
T54	White potatoes:	4 100	2 340	2
		3 800	2 800	4
		4 500	2 980	3
		4 000	2 830	5
	Mean	4 100	2 740	3.5
T55	Sweet potatoes:	2 600	2 460	12
		3 500	2 470	NA
		2 700	1 820	14
		1 900	765	NA
	Mean	2 680	1 880	13
	White potatoes:	4 000	3 090	3
		4 000	3 610	2
		4 300	3 300	3
	Mean	4 100	3 330	2.7
T56	Tomatoes:	2 500	1 690	3
		2 300	1 210	3
	Squash:	2 300	1 410	8
	Papaya:	2 500	2 060	8
	Sorghum:	3 100	4 110	40
	Guava:	2 000	937	NA
	Sweet potatoes:	2 500	1 130	NA
	Corn:	1 900	1 100	NA
T57	White potatoes:	3 700	4 320	[b] 42
		4 100	3 040	1
		3 800	2 010	1
		4 400	2 050	4
		4 600	2 880	6
	Mean	4 120	2 860	3.0
1971:				
T52	Collard greens:	3 500	1 300	84
		4 100	3 300	
		3 000	2 900	46
		3 400	3 100	5
	Mean	3 500	2 650	45
	Corn:	2 200	2 000	NA
	Okra:	3 600	3 600	35
T54	Collard greens:	3 900	4 200	NA
	Cabbage:	2 600	2 200	NA
	White potatoes:	3 400	3 200	4
	Corn:	2 400	2 100	NA
T55	Corn:	1 800	980	<1
		1 600	1 200	NA
		2 000	2 200	NA
	Mean	1 800	1 460	<1
	White potatoes:	3 500	3 000	2
		4 200	3 600	NA
	Tomatoes:	3 000	1 100	NA
T56	Corn:	1 900	1 000	<1
		1 800	1 300	NA
		2 300	1 800	NA
		2 500	2 400	NA
		2 600	2 500	NA
	Mean	2 220	1 800	<1
	White potatoes:	3 600	3 900	3
		3 500	3 400	NA
	Squash:	2 200	1 200	NA
	Beets:	2 900	2 180	NA
T57	Cabbage:	4 600	1 500	30
		3 800	3 100	NA
		2 200	1 900	NA
	Mean	3 530	2 170	30
	White potatoes:	3 800	3 300	NA
	Green beans:	5 600	3 500	NA
	Sorghum:	3 000	3 100	NA

[a] Includes potassium-40.

[b] Stranger, not used in calculation of mean.

NA, no analysis.

Preoperational Levels of Environmental Radioactivity in Water and Sediment Around Turkey Point Nuclear Power Plants, Card Sound, Florida

Tod S. Johnson and Thomas D. Pemble[1]

An investigation of the levels and distribution of gross alpha, gross beta and selected gamma-emitting radioisotopes present in water and sediment samples from Card Sound, Fla. was performed. This environmental radioactivity baseline study, was carried out between January 1971 and June 1972, prior to operation of the Turkey Point Nuclear Power Plants and discharge of liquid effluents from these plants into Card Sound.

This report describes the levels of radioactivity in seawater and sediment samples from Card Sound, a small bay approximately 5 miles long and 3 miles wide, located on the southeast coast of Florida (figure 1). This area was studied because Florida Power and Light Co. (FPL) was constructing a 6-mile long canal for use in cooling effluent water from two nuclear power plants under construction at Turkey Point and planned to discharge the effluent water from the canal into Card Sound.

The radionuclide data reported in this paper were obtained in collaboration with investigators at the University of Miami Rosenstiel School of Marine and Atmospheric Sciences.[2] During the reporting period (January 1971 to June 1972) many of the same sample stations and sample periods were used cooperatively for collection of samples and extensive work (i.e. chemical, biological and physical studies) has been carried out by other investigators,[3] thereby allowing cross-correlation of data.

Sample collection and analysis

Card Sound water and sediment samples were collected at various times between January 1971 and June 1972, i.e. prior to operation of the Florida Power and Light nuclear power plants at Turkey Point. Initially, surface and bottom water samples were collected at each station using 1 liter polyethylene bottles. The last four sample periods were limited to a single "representative" sample from each station (either top or bottom). Bottom water samples were obtained using a modified Niskin bottle, while surface samples were taken by hand. The coded bottles were then brought to the laboratory, chilled in a refrigerator, and 1-liter aliquots from each sample transferred to plastic bags (#0.003),[4] heat sealed with a

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[2] Collaborating investigators: Douglas Segar, Ph.D. and Sol Gerchakov, Ph.D., Chemical Oceanography Department, and Mr. Kenneth O. Barry, Computer Services, Rosensteil School of Marine and Atmospheric Sciences.

[3] The overall collaborative program was entitled "An Ecological Study of South Biscayne Bay and Card Sound, Florida" (Dr. Richard G. Bader and Dr. Martin A. Roessler, principal investigators). The work covered in the present report was sponsored by a grant from the U.S. Atomic Energy Commission (AT-(401)-3801) and the Florida Power and Light Co.

[4] Seal-Tite Plastic Packaging Co., P.O. Box 66, Perrine, Fla. 33157.

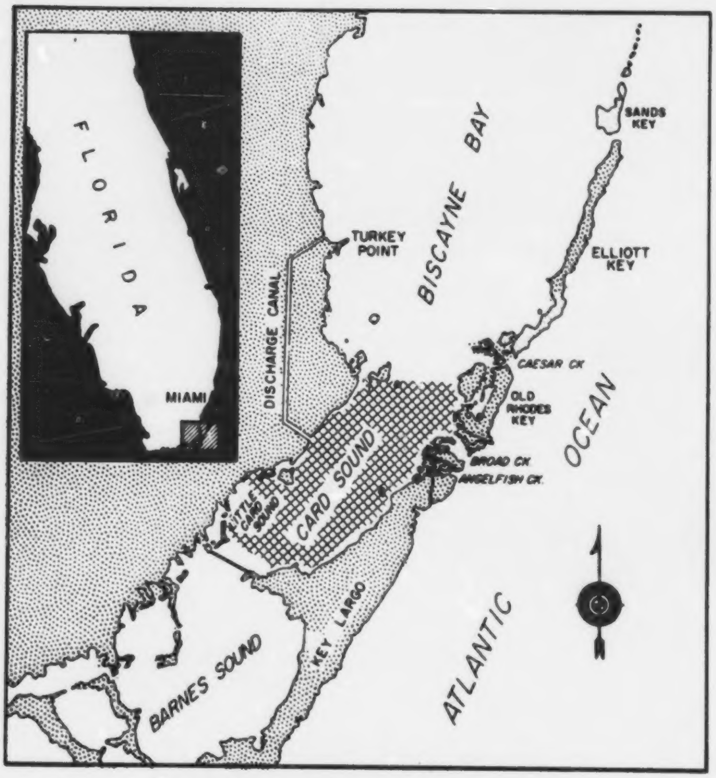

Figure 1. Geographical location of the Card Sound study area in relation to FPL Turkey Point discharge canal

Thermal-Impulse Sealer and placed in cylindrical (7 × 14.6 cm) containers for counting.

The gamma counting system consisted of a heavily shielded counting chamber (6-inch steel walls with ⅛ inch lead and several layers of ⅛ inch tin) housing two matched 4 by 8-inch Harshaw NaI(Tl) crystals, each with three photomultiplier tubes and a mixer. The signals from the mixers feed to an anticoincidence unit, then to a preamplifier and a Nuclear Data Model 180, multi-channel analyzer. Data acquisition and storage was achieved by use of a Cypher Model 7H magnetic tape unit. The analyzer system was calibrated at 5 keV/channel using a combination disc source of cesium–137 and cobalt–60, with routine background, linearity and zero shift checks made several times a week.

Following gamma counting, each 1 liter sample was suction filtered[5] using a Buchner funnel with 9-cm diameter No. 40 Whatman filter paper disc and the suspended solids fraction prepared for planchet[6] counting following the method previously described by Porter et al. (*1*). The dissolved solids fraction of filtered seawater was evaporated overnight using a heated mineral oil bath, air dried, and weighed; then 1 g planchet samples were prepared using the method of Porter et al. (*1*). The gross alpha and gross beta activities were then determined using a Nuclear-Chicago Model 1152 low-background, gas proportional counter.

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[5] Although carbonate precipitation with chemical fractionation is a more sensitive determination of salt water alpha and beta activities, the simple, widely-used filtration-evaporation method was adequate for the baseline reactor preoperation study.

[6] Nuclear-Chicago Model 3310 2-inch diameter aluminum planchets were used in the study.

Sediment samples were collected with a hand corer at most stations and placed in 300 ml polypropylene bottles, returned to the laboratory and air dried at 30° C. using a temperature controlled oven. Each sample (95–240 g) of dried sediment was analyzed for the presence of selected gamma emitters using counting conditions similar to those described for seawater. After completion of the gamma counting of the individual samples for each sample period, composite samples were prepared and counted for the different sediment types (i.e. fibrous peat, fine mud, mud, or sandy) to allow for better comparison of the gamma radionuclide concentrations in the various sediment types.

Standardization and computer data analysis

The gamma spectrum analyses for determination of gamma ray energies and intensities of selected gamma emitters in Card Sound seawater and sediment samples were carried out using a modified Fortran IV, linear least squares fitting program described by Helmer, et al. (*2*) having zero-shift, gain-shift and intensity correction routines. The original gamma spectrum analysis program was written for the IBM 7040 Computer. The program was converted for use on the IBM 360/65 and Univac 1106 system and presently includes numerous updates and useful subroutines not available in the original program.

Calibrated, gamma-emitting standards were obtained from the Analytical Quality Control Service (AQCS), Bureau for Radiological Health,[7] and used to determine the photopeak counting efficiencies and minimal detectable activities[8] for the reported study. One liter water and sediment gamma standards were prepared by spiking either distilled water or ACS grade sodium chloride (density approximates sediment samples) with the appropriate gamma emitters for water and sediment standards, respectively. Following background subtraction and any gain-shift or zero-shift corrections, these data were then used as standardized gamma spectral input for the computer program. For each sample, the program calculates an intensity factor for each standard ± standard deviation and expresses the calculated activity of each standard emitter in appropriate units (i.e. per unit volume or unit weight).

Calibrated plutonium–239 and strontium-yttrium–90 sources were obtained from AQCS for use as alpha and beta standards, respectively. The final gross alpha and gross beta values were corrected for appropriate background, counting efficiency, backscatter and transmission factors.

Results and discussion

Selected gamma radioactivity, seawater

The results of gamma spectral analysis carried out on Card Sound water samples taken between January 1971 and June 1972 are listed in table 1. The gamma analysis data indicated that the concentrations of the short half-life radionuclides (iodine–131, zirconium–95, and barium–140) as well as manganese–54, zinc–65, and sodium–22 were consistently nondetectable throughout the reporting period. Those gamma emitters having longer half-lives were present in detectable quantities in the water samples during the reporting period (table 1). Calculated mean activities for the longer-life species were indicative of a low background, marine system. For water samples, in general, there were no significant statistical differences at the 0.05 confidence level in the mean gamma emitting radionuclide concentrations between samples taken at different stations and only minimal variations between sample periods. Cerium–144 activities in water samples were consistent within each sample group, but showed statistically significant differences at the 0.05 confidence level in the mean concentration values when compared between sample periods (ranging from 48–253 pCi/liter). The higher values obtained for cerium–144 during the late sampling periods (1972) were due partly to improved cerium–144 counting conditions (i.e. reduction in the low energy background "noise" detected by the counting system).

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[7] Now part of the Office of Research and Development, U.S. Environmental Protection Agency.

[8] Minimal detectable activities (MDA) = 3 $\sqrt{\text{background}}$.

Table 1. Selected gamma radioactivity in Card Sound water samples[a]

Date collected	Number of samples	Mean radionuclide concentrations (pCi/liter)					
		^{144}Ce	^{106}Ru	^{137}Cs	^{54}Mn	^{60}Co	^{40}K
11-13-70	40	62 ±18	44 ±7	16 ±4	[b] T	T	212 ±23
2-17-71	75	48 ±20	T	ND	ND	ND	213 ±18
3-24-71	70	54 ±17	38 ±4	T	T	ND	200 ±19
6-22-71	55	218 ±29	43 ±6	17 ±5	ND	13 ±5	225 ±18
10-3-71	56	189 ±26	T	22 ±6	ND	T	241 ±22
1-11-72	50	253 ±37	46 ±6	T	ND	14 ±6	225 ±31
6-6-72	52	217 ±23	35 ±7	15 ±5	T	11 ±4	310 ±30

[a] Sodium-22, zinc-65, zirconium-95, iodine-131, and barium-140 were not detected in any sample.

[b] Trace level, i.e., equal to MDA for that radionuclide, but occurring in >50 percent of the samples for that group, where $MDA = 3\sqrt{BKD}$.

[c] ND, nondetectable. Below background of counting system.

There were no statistically significant differences in means or variance between surface and bottom water sample gamma activity at the 95-percent confidence limit within each sample period. With the exception of cerium-144, only minimal differences in selected gamma radioactivity occurred during the entire reporting period.

Selected gamma radioactivity, sediments

The results of gamma analyses for sediment samples from Card Sound are listed in table 2. The mean gamma radioactivity concentrations (pCi/kg dried sediment) for the four sample groups between February 1971 and May 1972 showed significant differences between the first two sample periods and the final two sample periods. This was due partly to improved counting conditions (i.e. lower background), but mainly to the higher proportion of peat-type sediment samples present in the June 1971 and May 1972 collection periods. In general, the mean activities for selected gamma-emitting radionuclides ranged from nondetectable for iodine–131, zirconium–95, manganese–54, and barium–140 to greater than 1000 pCi/kg for cerium–144 (table 2).

When the composite samples were analyzed for each of the sampling periods and the mean activities of the different gamma emitters compared for the major sediment types (i.e. fibrous peat, mud, and sandy), it became apparent that the sediment-associated gamma radioactivities were not equally distributed between the sediment types (table 2). For example, the overall mean gamma concentrations of dried sediment for fibrous peat were greater than mud which were greater than sandy sediment. These differences in sediment-associated radioactivity could be important in influencing the distribution, availability, and ultimate uptake of biologically important radionuclides in Card Sound. A previous study (*3*) indicated that the movements of sediments in Card Sound are dominated by tidal circulation and wind-generated waves and currents, which distributes the coarser sediment in the upper and mid-portions of the sound, while the finer sediment materials are transported to and deposited across Card Bank. Assuming the sediment accociated radioactivity is dependent upon sediment type and radioactivity concentration increases with decreasing particle size (*4*) and based on hydrological and chemical analyses data obtained in the Card Sound study (*5,6*), one would expect the sediment in the Card Bank and adjacent areas (figure 2) to accumulate the highest concentrations of radioactivity derived from the Turkey Point reactor effluent discharges into Card Sound.

Gross alpha and beta radioactivity, Card Sound water

The results for the gross alpha and gross beta analyses of the 380 Card Sound water samples studied between November 1970 and June 1972 are listed in table 3. The gross alpha activities ranged from <3 pCi/liter (overall average also <3 pCi/liter) for suspended solids to means of 13–46 pCi/liter (overall mean 35

Table 2. Selected gamma radioactivity in Card Sound sediment samples

Date collected	Number of samples	Mean radionuclide concentrations (pCi/kg dry weight)										
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{65}Zn	^{60}Co	^{22}Na	^{40}K	^{140}Ba
2/17/71	72	691 ±60	ND	173 ±25	68 ±15	[a]T	T	20 ±12	48 ±15	27 ±12	480 ±55	ND
3/24/71	68	740 ±97	T	156 ±40	61 ±28	ND	ND	23 ±16	38 ±20	23 ±17	666 ±68	ND
6/22/71	36	925 ±115	ND	175 ±38	59 ±30	20 ±10	T	T	63 ±25	32 ±19	632 ±77	ND
5/6/72	24	1 010 ±222	T	212 ±60	88 ±32	30 ±21	T	28 ±16	68 ±24	30 ±20	682 ±71	ND
Composities												
2/17/71												
Sand	[b]3 (19)	435 ±40	ND	134 ±15	62 ±9	ND	ND	25 ±17	36 ±3	18 ±11	297 ±38	ND
Mud	3 (27)	656 ±51	T	149 ±12	68 ±11			20 ±7	42 ±12	23 ±5	517 ±53	ND
Peat	3 (26)	1 120 ±100	T	235 ±22	92 ±22	16 ±16	20 ±5	ND	85 ±20	35 ±7	1 060 ±182	ND
3/24/71												
Sand	3 (21)	416 ±36	ND	98 ±8	32 ±8	ND	ND	ND	22 ±8	21 ±11	229 ±18	ND
Mud	2 (14)	690 ±74	T	125 ±15	65 ±21	ND		31 ±8	28 ±6	T	544 ±49	ND
Peat	3 (20)	988 ±66	ND	222 ±27	90 ±15	T	31 ±12	48 ±21	77 ±19	40 ±8	1 220 ±125	ND
6/22/71												
Sand	2 (7)	415 ±33	ND	86 ±7	32 ±7	18 ±6	ND	ND	23 ±7	17 ±8	264 ±48	ND
Mud	2 (12)	591 ±51	ND	115 ±22	48 ±21	ND	T	ND	33 ±9	26 ±10	487 ±46	ND
Peat	2 (14)	1 290 ±76	T	281 ±37	85 ±21	25 ±7	23 ±5	40 ±18	96 ±21	42 ±14	1 150 ±98	ND
5/6/72												
Sand	1 (5)	452 ±39	ND	99 ±9	33 ±8	ND	ND	19 ±10	29 ±9	27 ±12	310 ±41	ND
Mud	2 (7)	639 ±55	ND	150 ±25	58 ±16	20 ±10	T	ND	52 ±17	30 ±6	499 ±46	ND
Peat	2 (12)	1 510 ±128	T	305 ±44	115 ±26	44 ±18	28 ±13	37 ±18	105 ±15	36 ±10	997 ±79	ND

[a] Trace level, i.e., equal to MDA for that radionuclide, but occurring in >50 percent of the samples for that group. Where MDA = $3\sqrt{\overline{BKD}}$.
[b] Number in parentheses is the total number of individual samples included in the determination of the mean.
ND, nondetectable. Below background of counting system.

Table 3. Gross alpha and gross beta activity in Card Sound water

Date collected	Number of samples	Surface samples (pCi/liter)				Bottom samples (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
		Gross alpha	Gross beta	Gross alpha	Gross beta	Gross alpha	Gross beta	Gross alpha	Gross beta
1-13-71	38	<3	<6	[a] 13 ±29	251 ±107	<3	<6	32 ±40	266 ±92
2-17-71	71	<3	<6	46 ±40	259 ±71	<3	<6	30 ±36	236 ±70
3-24-71	70	<3	<6	35 ±31	265 ±80	<3	<6	38 ±23	252 ±83
6-22-71	48	<3	<6	40 ±31	255 ±69	<3	<6	41 ±29	259 ±91
10-3-71	56	<3	<6	37 ±30	273 ±75	<3	<6	33 ±35	271 ±67
1-11-72	50	<3	<6	32 ±30	260 ±78	<3	<6	45 ±32	282 ±76
6-6-72	48	<3	<6	28 ±23	280 ±85	<3	<6	32 ±27	272 ±88

[a] Mean ± standard deviation.

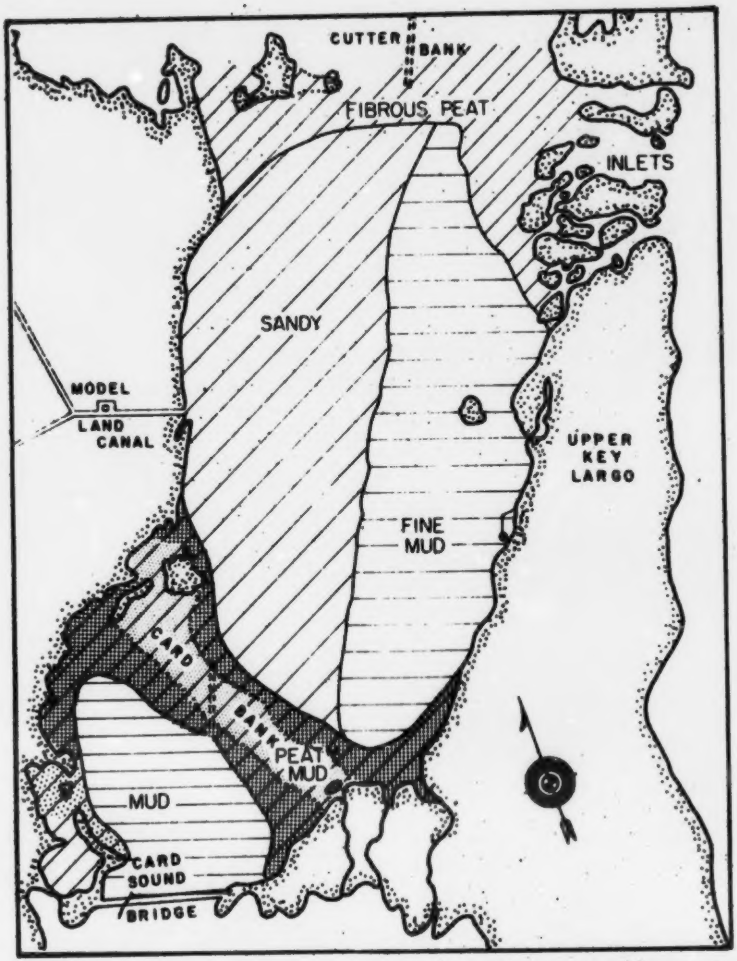

Figure 2. Card Sound system, showing approximate distributions of major sediment types (5), and projected regions of maximum sediment-associated radioactivity

pCi/liter) for the dissolved solids. Mean for gross beta radioactivity values for suspended solids and dissolved solids were <6 pCi/liter (overall mean <6 pCi/liter) and 251–282 pCi/liter (overall mean 263 pCi/liter), respectively.

Analyses of alpha and beta radioactivity data for the seven sampling periods covered in this report indicated that for both alpha and beta groups, there were no statistically significant differences in means at 0.05 level or variance at T + 0.05 (in general) between surface and bottom samples, between the means from different sample stations within each sample period, or between the means for the different sampling periods. Thus, the results of the gross alpha and gross beta radioactivity concentrations in Card Sound water samples during the reporting period were indicative of a low-background marine ecosystem with alpha or beta activity uniformly distributed throughout the entire body of water studied (figure 1).

Conclusions

The pre-Turkey Point Nuclear Power Plant operation levels of gross alpha, gross beta and selected gamma radioactivity in Card Sound water during the reporting period (January 1971 to June 1972) were representative of a low-background, marine environment. These low-level radioactivities were randomly distributed throughout the small bay.

Sediment-associated, selected gamma radioactivity results suggest that the activities in dried sediment are distributed disproportionally between the major sediment types in Card Sound (i.e. fibrous peat > mud > sandy). These results, together with available hydrological (*5,6*) and sediment distribution data (*3*) would indicate the Card Bank and adjacent areas could be expected to show the highest sediment-associated radioactivity to be derived from FPL Turkey Point Nuclear Power Plant discharges into Card Sound.

The low-background randomly distributed levels of the radioactivity (gross alpha, gross beta and selected gamma) in Card Sound water prior to the operation of the Turkey Point Nuclear Power Plants provides a baseline for future studies designed to interpret radionuclide levels and distribution in Card Sound water during the period of FPL nuclear power plant effluent discharge into this marine ecosystem.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Procedures for determination of stable elements and radionuclides in environment samples, PHS No. 999–RH–10. Division of Radiological Health (1965); pp 3–1 to 3–12.

(*2*) HELMER, R. G., R. O. HEATH, L. A. SCHMITTROTH, M. A. JAYNE and L. M. WAGNER. Analysis of gamma-ray spectra from NaI(Tl) and Ge(Li) spectrometers—computer programs. Nucl Instru Methods 47:305–319 (1967).

(*3*) EARLEY, C. F. and H. G. GOODELL. The sediments of Card Sound, Florida. J Sedim Petrology 38:985–999 (1968).

(*4*) JOHNSON, Jr., R. H., and J. H. ABRAHAMS, Jr. Soil and sediment analysis: preparation for samples for environmental radiation surveillance, PHS Publication No. 999–RH–19. Division of Radiological Health (1966).

(*5*) An ecological study of South Biscayne Bay and Card Sound. Progress Report to US AEC (AT–(401)–3801–3) and Florida Power and Light Company (July 1971).

(*6*) An ecological study of South Biscayne Bay and Card Sound. Progress Report to US AEC (AT(40–1)–3801–4) and Florida Power and Light Company (June 1972).

SECTION I. MILK AND FOOD

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon–14 in Total Diet and Milk	1972–1973	November 1973
Strontium–90 in Tri-City Diets	1972	December 1973

125

Radionuclides in Institutional Diet Samples, April–June 1973

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1,2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice

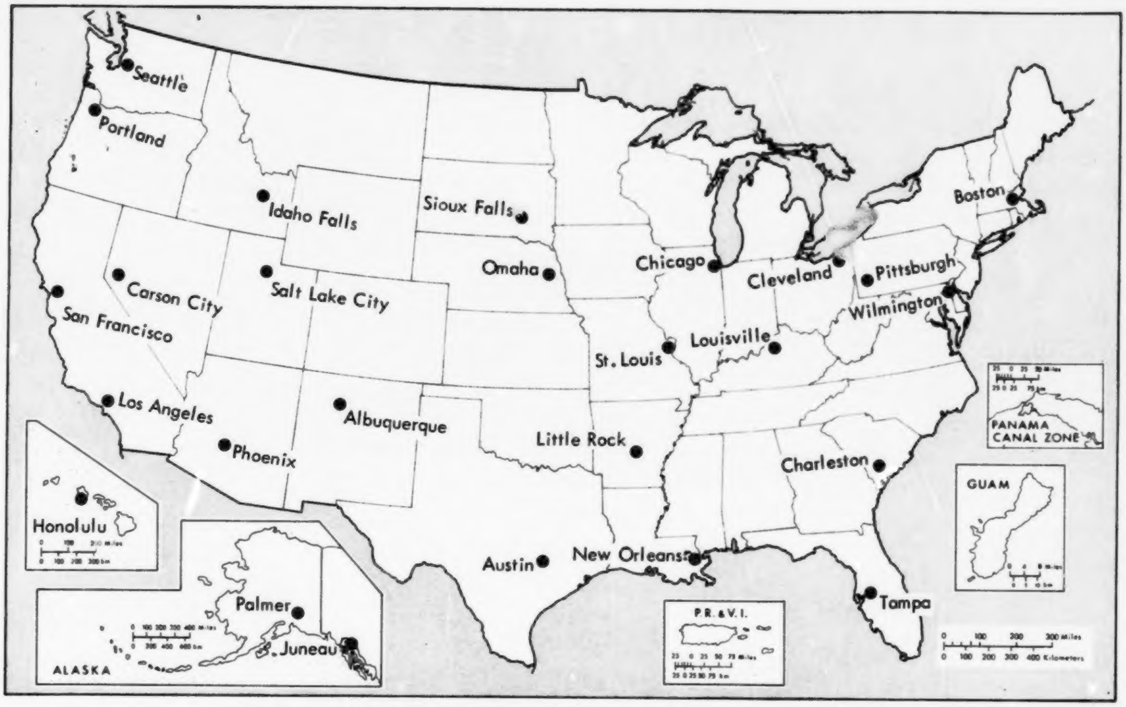

Figure 1. Institutional diet sampling locations as of June 1973

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children April-June 1973

Location of Institution		Month [a] (1973)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	April [b]	1.98	0.5	1.1	1.1	2.2	3	7	0	0
	Palmer		NS								
Ariz:	Phoenix	April	2.03	.6	1.2	1.5	3.0	3	6	0	0
Ark:	Little Rock	April	1.55	.6	1.0	1.8	2.8	0	0	0	0
Calif:	Los Angeles		NS								
	San Francisco	April [b]	1.66	.5	.8	1.8	3.0	3	5	0	0
Del:	Wilmington	April	1.56	.7	1.1	1.3	2.0	6	9	0	0
Fla:	Tampa	April	1.63	.5	.9	1.2	1.9	4	6	0	0
Hawaii:	Honolulu	April	2.49	.5	1.3	1.5	3.7	4	6	14	23
Idaho:	Idaho Falls	April [b]	1.75	.7	1.2	1.6	2.7	4	10	0	0
Ill:	Chicago		NS					7	13	0	0
Ky:	Louisville		NS								
La:	New Orleans	April [b]	2.10	.5	1.0	1.5	3.3	6	13	0	0
Mass:	Boston	May	2.08	.6	1.2	1.5	3.2	4	7	0	0
Mo:	St. Louis	April [b]	1.25	.6	.8	1.9	2.4	4	5	0	0
Nebr:	Omaha	April [b]	2.41	.9	2.1	1.6	3.9	3	7	0	0
Nev:	Carson City	April	1.24	.5	.7	1.7	2.1	3	3	0	0
N. Mex:	Albuquerque	April [b]	1.74	.6	1.0	1.5	2.6	4	7	0	0
Ohio:	Cleveland		NS								
Oreg:	Portland	April [b]	2.07	.5	1.1	1.8	3.8	3	5	0	0
Pa:	Pittsburgh	April [b]	3.20	.4	1.2	1.3	4.1	3	10	13	42
S.C:	Charleston	April	.90	.5	.5	1.6	1.4	6	5	17	15
S. Dak:	Sioux Falls	April	.92	1.3	1.2	1.8	1.6	10	9	0	0
Tex:	Austin	April [b]	1.30	.6	.8	1.9	2.4	4	5	0	0
Utah:	Salt Lake City	April [b]	2.17	.4	.9	1.2	2.7	0	0	0	0
Wash:	Seattle	April [b]	1.87	.7	1.4	1.5	2.8	4	7	0	0
Institutional average			1.81	0.6	1.1	1.6	1.7	4	7	2	4

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during April–June 1973. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.81 kg/day compared to the network average of 1.84 kg/day observed from 1961 through 1972.

Strontium–90 dietary intake averaged 7 pCi/day during this period. Cesium–137 intake averaged 4 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium–89, barium–140, and iodine–131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium–89, 5 pCi/kg; strontium–90, 2 pCi/kg; iodine–131, 10 pCi/kg; barium–140, 10 pCi/kg; cesium–137, 10 pCi/kg.

This is the last data article for the Institutional Diet Sampling Program since this network was discontinued effective June 30, 1973.

Recent coverage in *Radation Data and Reports:*

Period	Issue
April–June 1972	July 1973
July–September 1972	August 1973
October–December 1972	September 1973
January–March 1973	November 1973

127

REFERENCES

(*1*) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 (September 1961).

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium–226 and strontium–90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	January–December 1972	December 1973
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Minnesota Municipal Water Supplies[1]
July 1971–June 1972

Division of Environmental Health
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul. Beginning in November 1969, weekly samples from these stations were composited and analyzed on a monthly basis. Monthly samples are taken at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 500-ml sample of water is evaporated into a 2-inch aluminum

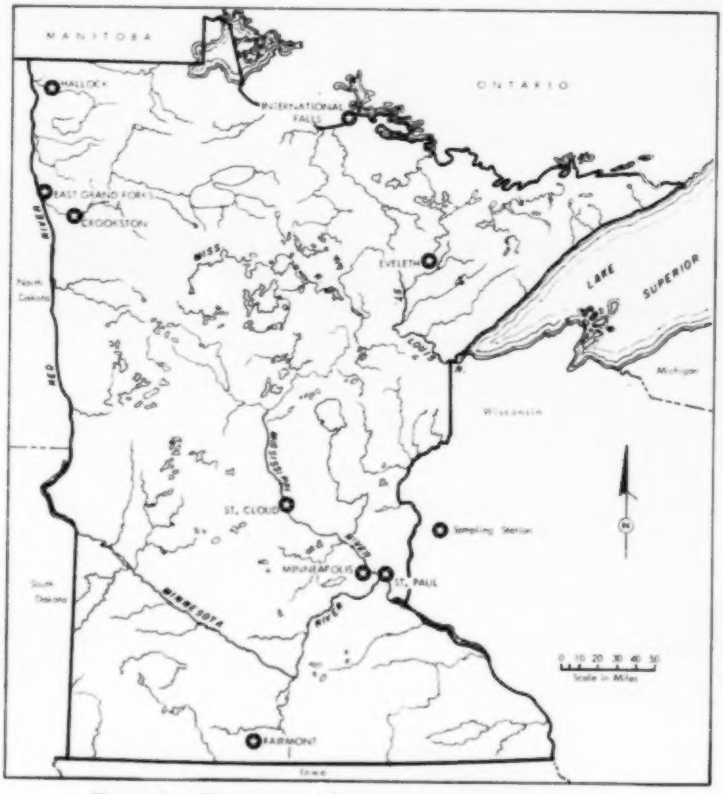

Figure 1. Minnesota surface water sampling locations

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[1] Data and information from "Survey of environmental radioactivity, July 1971–June 1972," Publication No. C00-651-87. Minnesota Department of Health, 717 Delaware St. S.E., Minneapolis, Minn. 55440.

Table 1. Average gross beta radioactivity in Minnesota raw and treated water supplies, July 1971-June 1972

Town and water source	Type of water	Average concentration (pCi/liter)											
		1971						1972					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	22	21	18	18	35	17	17	22	18	14	17	19
	Treated	22	16	16	17	13	19	16	20	18	11	14	15
East Grand Forks, Red River Lake	Raw	21	17	19	20	18	16	18	19	16	13	14	17
	Treated	6	8	10	15	11	9	6	7	10	9	8	7
Eveleth, St. Mary's Lake	Raw	13	12	12	12	7	7	10	11	11	13	9	8
	Treated	9	10	12	12	10	9	10	9	9	9	11	7
Fairmont, Budd Lake	Raw	9	11	9	11	9	8	15	8	8	9	8	8
	Treated	6	6	5	11	5	3	7	4	4	5	6	3
Hallock, Two Rivers South Fork	Raw	21	16	16	13	12	16	19	19	16	10	14	13
	Treated	8	6	7	7	4	7	9	14	7	8	6	7
International Falls, Rainey River	Raw	12	9	8	7	8	6	4	8	6	4	10	7
	Treated	24	9	6	7	4	5	4	6	3	6	5	6
Minneapolis tap water	Treated	9	4	7	13	5	4	6	<2	5	5	8	6
St. Cloud, Mississippi River	Raw	NS	10	9	9	14	8	6	NS	6	10	NS	9
	Treated	NS	7	5	4	8	5	4	NS	3	3	NS	5
St. Paul, Vadnais Chain of Lakes	Raw	15	10	11	12	12	13	10	10	11	10	10	8
	Treated	8	7	8	9	6	5	6	7	8	5	6	6

NS, no sample.

Table 2. Average gross alpha radioactivity in Minnesota raw and treated water supplies, July 1971-June 1972

Town and water source	Type of water	Average concentration (pCi/liter)											
		1971						1972					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<3	<4	<3	<4	15	<4	<2	<2	<2	3	<4	<4
	Treated	<2	<2	<3	<3	4	<4	<3	<2	<2	<2	<3	<3
East Grand Forks, Red River Lake	Raw	<3	<4	<4	6	<4	<3	7	<3	<2	<2	<5	<4
	Treated	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Eveleth, St. Mary's Lake	Raw	<2	<2	<2	<3	<1	<3	<2	<1	<2	<2	<1	<2
	Treated	<2	<2	<2	<2	<1	<2	2	<2	<2	<2	<2	<2
Fairmont, Budd Lake	Raw	<2	<4	<1	<4	6	7	17	4	5	<4	<3	6
	Treated	<2	<2	<2	<2	<2	<2	6	3	<2	<2	<2	<2
Hallock, Two Rivers South Fork	Raw	<5	<5	<6	<4	<3	<4	11	<5	<5	<4	<4	<4
	Treated	<2	<2	<2	<3	<2	<2	<3	<3	<3	<2	<2	<2
International Falls, Rainey River	Raw	<1	<1	<1	<1	<1	<1	<2	<2	<1	<1	<1	<1
	Treated	<2	<2	<1	<1	<1	<1	<2	<2	<1	<2	<1	<1
Minneapolis tap water	Treated	<2	<2	<1	<4	<2	<2	<3	<2	<2	<2	<2	<2
St. Cloud, Mississippi River	Raw	NS	<3	<1	<2	6	<3	<2	NS	<2	<2	NS	<4
	Treated	NS	<3	<1	<1	<2	<2	<2	NS	<2	<7	NS	<2
St. Paul, Vadnais Chain of Lakes	Raw	<3	<2	<3	<3	<2	<3	<2	<2	<3	<3	<3	<2
	Treated	<2	<2	<2	<2	<2	<2	<3	<2	<2	<2	<2	<2

NS, no sample

milk bottle lid planchet and counted in an internal-proportional gas flow counter. The counter is calibrated with a cesium-137 standard.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal supplies from July 1971–June 1972. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 35 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July 1970–June 1971	November 1972

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered in *Radiation Data and Reports.*

Network	Period reported	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring program	January–June 1973	December 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1971	September 1973

Krypton-85 in Air, July 1970 to December 1972

Eastern Environmental Radiation Facility
U.S. Environmental Protection Agency

Krypton–85 in the atmosphere results from natural production by cosmic ray interactions, thermonuclear detonations, and atmospheric releases from several components of the nuclear power industry. Monitoring of krypton–85 in the atmosphere has been conducted to identify baseline levels and trends in anticipation of a nationwide expansion of the nuclear power industry.

The analytical results for 1970–1972 are presented in table 1. The krypton–85 in air data are presented for several locations throughout the United States, selected with respect to existing and proposed nuclear power reactor and nuclear fuel reprocessing plant locations. Dry, compressed air samples were purchased from commercial air suppliers and analyzed for krypton–85 by the method of Cummings, et al. (*1*).

The analysis of krypton–85 in air will continue as a component of the Environmental Radiation Ambient Monitoring System (ERAMS) and the data reported in *Radiation Data and Reports* on a semiannual basis.

REFERENCE

(*1*) CUMMINGS, S. L., R. L. SHEARIN, and C. R. PORTER. A rapid method of determining ^{85}Kr in environmental air samples. Proceedings of the International Symposium on Rapid Methods for Measurement of Radioactivity in the Environment (1971), pp. 163–169.

Table 1. Krypton–85 in air, July 1970 to December 1972

Location		Krypton-85 concentration (pCi/m³ of air at STP [a])							
		1970		1971				1972 [b]	
		July 1–Sept 30	Oct 1–Dec 31	Jan 1–March 31	April 1–June 30	July 2–Sept 30	Oct 1–Dec 31	Jan 1–March 31	April 1–June 30
Ala:	Montgomery	—	—	15.8	15.2	14.3	14.7	13.8	14.4
Calif:	Long Beach [c]	—	14.8	14.4	14.6	14.4	—	—	14.3
	Oakland	—	—	—	14.6	14.2	14.5	15.1	14.3
Colo:	Denver [c]	16.2	16.9	—	—	—	—	16.4	—
Fla:	Tampa	—	—	14.4	14.2	14.3	—	12.8	15.1
Ill:	Chicago	—	—	—	14.7	14.5	15.5	14.2	—
Mass:	Boston	—	15.2	15.2	—	14.8	14.9	—	15.4
Mich:	Detroit	—	14.4	15.8	13.9	14.7	14.6	15.5	15.7
N.J:	Camden	—	15.6	15.2	14.7	13.7	15.1	13.6	16.3
N.Y:	Buffalo	—	—	14.9	15.7	14.8	15.9	16.1	15.4
	Rochester [c]	—	—	—	15.2	—	—	—	—
	Utica	—	—	—	15.1	14.1	14.7	14.7	14.6
N.C:	Greensboro	—	15.7	14.7	14.4	14.5	14.8	15.7	15.0
Okla:	Oklahoma City	—	—	14.9	14.5	13.6	15.0	14.8	14.2
Oreg:	Portland	—	—	—	—	15.1	—	—	—
Wash:	Spokane	—	—	—	—	—	—	—	14.8

[a] Standard temperature and pressure.
[b] No samples were collected for July-December 1972.
[c] 2σ error <±10 percent.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for Mound Laboratory and the National Reactor Testing Station.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Mound Laboratory[2]
January–December 1971

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio, about 12 miles southwest of Dayton. The laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; research, development and production of explosive materials; separation, purification, and sale of stable isotopes of the noble gases; and development, design and fabrication of radioisotopic heat sources for medical application and space exploration. The area within a 20-mile radius of the laboratory includes essentially all of Montgomery County and approximately 30 to 60 percent of the adjoining counties of Butler, Greene, Preble, and Warren. The predominant geographical feature in the five county region is the Great Miami River which flows through Miamisburg from the northeast to the southwest. This river valley area is generally highly industrialized. The remainder of the region is predominantly agricultural with some light industry and scattered residential communities. The primary agricultural activity in the area is raising field crops such as corn and soybeans. Approximately 10 percent of the land area in agricultural use is devoted to pasturing livestock (*1*).

Weather conditions in the area are considered moderate. The average annual precipitation is approximately 36 inches and is distributed evenly throughout the year. Winds predominate out of the south and west except during the summer months when a higher frequency is observed out of the southwest. The wind speed averages about 10 miles per hour annually (*2*).

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[2] Summarized from "Environmental Monitoring Report, January–December 1971 and 1971 Summary" (MLM 1922).

Interest in the health and safety of employees and the public is manifested by an Environmental Control Program which has been in existence continuously during the laboratory's history. Fundamental objectives of the environmental control program are the containment of radioactive waste and control of nonradioactive effluents to levels well within existing or proposed standards. As part of the program's control function, all effluents containing polluting materials are controlled at each operating step. As a result of this control, any releases of low-level gaseous and liquid wastes to the environment are carefully controlled and dispersed to ensure that concentrations are well within recommended standards.

Air monitoring

Air samples are collected offsite three times per week by means of a mobile sampling unit mounted in a panel truck. Samples are collected upwind and downwind as far as 20 miles from the laboratory covering an area of 1250 square miles. Specific collection routes are drawn for the different wind directions. The route is selected on any given day corresponding to the wind direction for that day. Figure 1 shows the zones corresponding to the eight sampling routes. The mobile unit is parked safely off the road while the sample is taken. Two types of samples are collected, a particulate sample for plutonium-238 and polonium-210 analysis and a gas bubbler sample for tritium oxide analysis. The particulate sample is collected on a 4-inch diameter Whatman No. 41 filter paper by means of a high volume air sampler. The air is sampled at a rate of 20 cubic feet per minute (0.57 m^3/

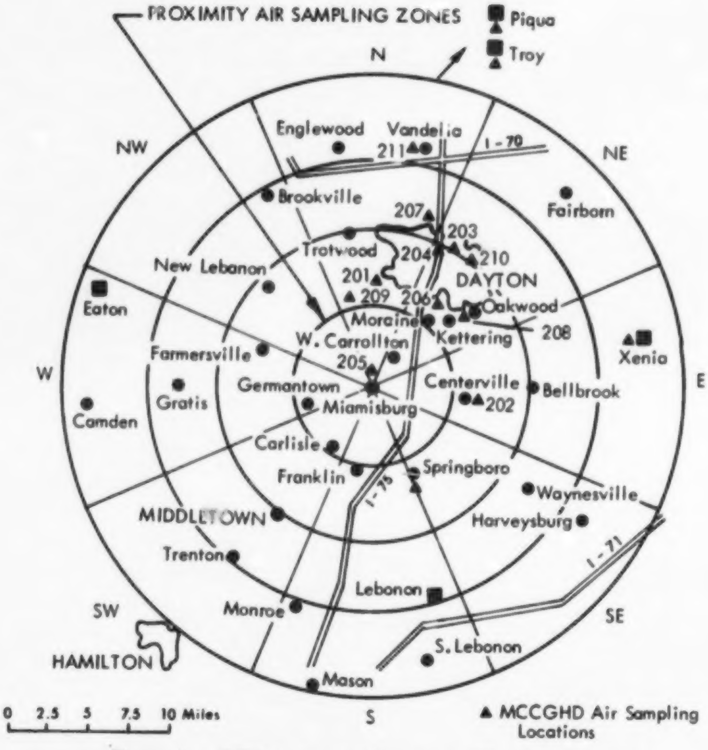

Figure 1. Offsite air sampling zones, Mound Laboratory

min). The particulate sample collected represents approximately 10 m^3 of air and is analyzed specifically for polonium–210 and plutonium–238. The plutonium–238 analysis includes the use of plutonium–236 as an internal standard in conjunction with alpha pulse-height analysis which allow for correction of chemical and counting losses to be made.

Analysis of the monitoring data for January–June 1971, shows that the average concentration of the polonium–210 measured at all locations upwind and downwind in all zones was only slightly above 0.1 percent of the AEC standard. The AEC standard is the concentration of radioactivity in the environment which is determined to result in whole body or organ doses which should not be exceeded without careful consideration. The data demonstrate that the average concentrations in all sampling areas were well below that level. The highest average concentration for this report period was 0.13 percent of the AEC standard in the 0–3 mile range upwind and 5–10 mile range downwind.

Analysis of the data obtained from samples collected by the mobile unit during July–December 1971 shows that the average concentrations of polonium–210 measured at all locations upwind and downwind in all zones were less than 0.3 percent of the AEC standard. The average concentrations over the entire year were approximately 0.2 percent of the AEC standard. These results are summarized in tables 1 and 2.

Table 1. Atmospheric monitoring for polonium–210, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average percent of AEC standard[b]
January-June 1971:			
0–3 (upwind)	70	9.5	0.13
0–3 (downwind)	70	8.1	.12
3–5 (downwind)	70	7.3	.10
5–10 (downwind)	70	9.4	.13
10–15 (downwind)	70	7.7	.11
15–20 (downwind)	70	6.7	.10
July-December 1971:			
0–3 (upwind)	64	14 ±8	.2
0–3 (downwind)	64	13 ±5	.2
3–5 (downwind)	64	14 ±8	.2
5–10 (downwind)	64	19 ±9	.3
10–15 (downwind)	64	18 ±9	.3
15–20 (downwind)	64	10 ±9	.1

[a] Lowest detectable limit for polonium–210 in air is 2 fCi/m^3.
[b] The applicable AEC radiation protection standard for polonium–210 in air is 7 pCi/m^3.

Table 2. Atmospheric monitoring for polonium–210 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average as percent of AEC standard[b]
0–3 (upwind)	134	12 ±8	0.2
0–3 (downwind)	134	10 ±6	.1
3–5 (downwind)	134	10 ±7	.1
5–10 (downwind)	134	14 ±8	.2
10–15 (downwind)	134	13 ±8	.2
15–20 (downwind)	134	9 ±5	.1

[a] Lowest detectable limit for polonium–210 in air is 2 fCi/m^3.
[b] The applicable AEC radiation protection standard for polonium–210 in air is 7 pCi/m^3.

Plutonium–238 concentrations measured in all zones for January–June were less than 1 percent of the AEC standard with a maximum of 0.57 percent occurring in the 0–3 mile range upwind. Plutonium–238 concentrations measured in samples collected by the mobile unit in all zones were less than 2 percent of the AEC standard. The average concentrations for the entire year were 1 percent of the AEC standard or less. Results for January–December 1971 are shown in tables 3 and 4. Samples are collected (at the same time that particulate samples of plutonium–238 and polonium–210 are taken) by bubbling air through 100 ml of p-dioxane-based scintillation fluid at a rate of 0.35 cubic feet per minute (9900 cm^3/min). Tritium oxide is collected in the p-dioxane solution, and a 20 ml aliquot of the resulting solution is counted directly for 10 minutes in a liquid

Table 3. Atmospheric monitoring for plutonium–238 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average as percent of AEC standard[b]
January-June 1971:			
0–3 (upwind)	72	1.70	0.57
0–3 (downwind)	72	1.36	.45
3–5 (downwind)	71	1.21	.40
5–10 (downwind)	66	1.35	.45
10–15 (downwind)	68	1.32	.44
15–20 (downwind)	64	1.33	.44
July-December 1971:			
0–3 (upwind)	44	3.19 ±0.47	1.1
0–3 (downwind)	44	5.58 ± .51	1.9
3–5 (downwind)	44	2.08 ± .38	.7
5–10 (downwind)	44	2.04 ± .38	.7
10–15 (downwind)	44	1.45 ± .32	.5
15–20 (downwind)	44	2.81 ± .36	.9

[a] Lowest detectable limit for plutonium–238 in air is 0.03 fCi/m^3.
[b] The applicable AEC radiation standard for plutonium–238 in air is 300 fCi/liter.

Table 4. Atmospheric monitoring for plutonium-238 Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (fCi/m^3)	Average as percent of AEC standard[b]
0-3 (upwind)	116	2.27 ±0.39	0.8
0-3 (downwind)	116	2.96 ± .37	1.0
3-5 (downwind)	115	1.54 ± .33	.5
5-10 (downwind)	110	1.63 ± .34	.5
10-15 (downwind)	112	1.37 ± .31	.5
15-20 (downwind)	108	1.93 ± .30	.6

[a] Lowest detectable limit for plutonium-238 in air is 0.03 fCi/m^3.
[b] The applicable AEC radiation protection standard for plutonium-238 in air is 300 fCi/m^3.

scintillation spectrometer. The sampling and analysis is directed to tritium oxide rather than the gas since the AEC standard for the oxide is 200 times more restrictive.

The highest average concentration of tritium oxide detected in the environment during January-June was 2.22 percent of the AEC standard in the 0-3 mile range downwind. The concentration diminished to less than 0.7 percent in the 3-5 mile range downwind. The average concentrations of tritium oxide measured during July-December varied approximately 6 percent of the AEC standard in one range (0 to 3 miles downwind) to 0.5 percent of the AEC standard. The average concentrations for the entire year varied from 4 percent to 0.5 percent of the AEC standard. These results are summarized in tables 5 and 6.

Table 5. Atmospheric monitoring for tritium, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (pCi/m^3)	Average as percent of AEC standard[b]
January-June 1971:			
0-3 (upwind)	71	409	0.58
0-3 (downwind)	71	1 557	2.22
3-5 (downwind)	71	473	.68
5-10 (downwind)	71	378	.54
10-15 (downwind)	71	357	.51
15-20 (downwind)	71	428	.61
July-December 1971:			
0-3 (upwind)	65	840 ±120	1.2
0-3 (downwind)	65	4 330 ±190	6.2
3-5 (downwind)	65	1 070 ±120	1.5
5-10 (downwind)	65	450 ±110	.6
10-15 (downwind)	65	360 ±110	.5
15-20 (downwind)	65	480 ±110	.7

[a] Lowest detectable limit for tritium in air is 50 pCi/m^3 for January-June and 40 pCi/m^3 for July-December.
[b] The applicable AEC radiation standard for tritium in air is 70 nCi/m^3.

Table 6. Atmospheric monitoring for tritium, Mound Laboratory environs, all zones, January-December 1971

Range (miles)	Number of samples	Average concentration[a] (pCi/m^3)	Average as percent of AEC standard[b]
January-December 1971:			
0-3 (upwind)	136	610 ±110	0.9
0-3 (downwind)	136	2 880 ±160	4.1
3-5 (downwind)	136	760 ±120	1.1
5-10 (downwind)	136	410 ±110	.6
10-15 (downwind)	136	360 ±110	.5
15-20 (downwind)	136	450 ±110	.6

[a] Lowest detectable limit for tritium in air is 40 pCi/m^3.
[b] The applicable AEC radiation standard is 70 nCi/m^3.

Additional particulate air samples are obtained from the Air Pollution Control Section of the Montgomery County Combined General Health District (MCCGHD). These samples are collected from various locations in Montgomery County. The locations also can be found in figure 1. The particulate sample in this case is collected on a 8 × 10 inch fiberglass filter by means of a high-volume air sampler. The air is sampled at a rate of 40 cubic feet per minute (1 m^3/min.) for a 24-hour period every 4 days. This sample represents approximately 1600 m^3 of air. The MCCGHD determines the weight of particulates collected and then submits one-half of the filter to Mound Laboratory which is analyzed specifically for polonium-210 and plutonium-238. The MCCGHD also supplies particulate data from the network to Mound Laboratory. Analysis of the data obtained from the MCCGHD particulate air samples during 1971 indicate that the average concentration of polonium-210 and plutonium-238 detected at any location was approximately 0.1 percent or less of the AEC standard. During the last quarter of 1971, additional particulate samples from communities outside Montgomery County were made available by the MCCGHD. While not as many samples were obtained from these locations as the Montgomery County locations, they are included for comparison since they are distant enough (19 to 34 miles) to be considered background for this general area. The concentrations of polonium-210 measured at the Montgomery County locations are approximately the same as the concentrations measured at the distant locations. The polonium-210 results are summarized in table 7. The concentra-

Table 7. Summary of Montgomery County combined General Health District air monitoring data for polonium–210, January-December 1971

Location	Average concentration (fCi/m^3)	Percent of AEC standard[a]
201	4.61 ±0.46	0.07
202	3.83 ± .39	.05
203	4.57 ± .46	.07
204	4.90 ± .47	.07
205	5.18 ± .47	.07
206	5.72 ± .50	.08
207	8.14 ± .71	.12
208	5.38 ± .47	.08
209	4.84 ± .45	.07
210	5.09 ± .45	.07
211	4.90 ± .46	.07
Piqua, Ohio[b]	7.84 ± .67	.11
Troy, Ohio[b]	7.80 ± .71	.11
Springfield, Ohio[b]	7.47 ± .66	.11
Springfield, Ohio[b]	7.47 ± .68	.11
Springfield, Ohio[b]	7.18 ± .64	.10
Fairborn, Ohio[b]	7.97 ± .70	.11
Xenia, Ohio[b]	8.04 ± .72	.11

[a] AEC standard = 7 pCi/m^3. Lowest detectable limit for polonium in air for MCCGHD samples is 0.01 fCi/m^3.

[b] Stations outside Montgomery County.

tions of plutonium–238 measured at the Montgomery County locations are of the same order of magnitude as the concentrations measured at the distant stations with the highest average value being a factor of 5 greater than the average value of the seven distant stations. This highest average value, however, is only 0.05 percent of the AEC standard. The plutonium–238 results are summarized in table 8. The data obtained from the MCCGHD samples indicate the increased sensitivity achieved by sampling a larger volume of air in comparison to the routine samples collected by the mobile unit (1000 m^3 vs 10 m^3). These data further demonstrate that the average concentrations of polonium–210 and plutonium–238 in the environment are well below the AEC standards.

Table 8. Summary of Montgomery County Combined General Health District air monitoring data for plutonium–238, January-December 1971

Location	Average concentration (aCi/m^3)	Percent of AEC standard[a]
201	26.5 ± 6.4	0.009
202	18.7 ± 4.9	.006
203	81.9 ±11.2	.027
204	19.1 ± 5.3	.006
205	77.6 ±10.5	.026
206	140.9 ±14.3	.047
207	40.1 ± 9.1	.013
208	19.6 ± 5.3	.007
209	117.7 ±13.3	.039
210	48.8 ± 8.2	.016
211	53.8 ± 8.8	.018
Piqua, Ohio[b]	32.7 ± 7.9	.011
Troy, Ohio[b]	25.2 ± 7.4	.008
Springfield, Ohio[b]	21.8 ± 6.4	.007
Springfield, Ohio[b]	18.9 ± 6.2	.006
Springfield, Ohio[b]	33.3 ± 8.0	.011
Fairborn, Ohio[b]	14.4 ± 5.4	.005
Xenia, Ohio[b]	42.5 ±10.0	.014

[a] AEC standard for plutonium–238 is 0.3 pCi/m^3. Lowest detectable limit for plutonium in air for MCCGHD samples is 1.9 aCi/m^3.

[b] Stations outside Montgomery County.

A continuously operating high volume air sampler and gas bubbler have been in operation in Miamisburg since the middle of September 1971. The sampler is located approximately 1 mile due north of the laboratory. The high volume sampler collects a particulate sample on a 200 mm diameter Microsorban disk. The sampling rate is 40 cubic feet per minute (1.1 m^3/min) resulting in a total sample volume of 10 000 m^3 of air. The gas bubbler sample also is collected on a continuous basis at approximately 1000 cm^3/min with a total volume of 10^3 m of air sampled. The average concentration of polonium–210 detected at the continuous high volume air sampling station in Miamisburg was only 0.03 percent of the AEC standard and the average concentration of plutonium–238 detected at this location was only 0.01 percent of the AEC standard. The average concentration of tritium oxide detected at this location was only 1 percent of the AEC standard. The data obtained from the continuous air sampling station demonstrates the increase in sensitivity achieved by collecting very large samples or air for both particulate samples (~10 000 m^3) and gas bubbler samples (10 m^3). A network of 10 continuous high volume air sampling stations is scheduled to be in operation by mid-February 1972 with an additional 10 planned to be in operation during the second half of 1972.

An onsite perimeter network of five continuous, high volume air samplers is scheduled for installation during the first half of 1972. In the interim, three sampling stations have been in operation. A continuous, high volume air sampler has been located at the southern site perimeter. The air is sampled at the rate of 40 cubic feet per minute (1.1 m^3/min). The remaining two sampling stations contain continuous low-volume air samplers. In these cases air is sampled at the rate of 1-cubic foot per minute (0.03 m^3/min). One low-volume station is located at approximately the center of the site and the other at the northern site perimeter. Gas bubbler samples at the rate of 1000 $cm^3/$ min also are collected at all three sampling locations. Both high and low volume particulate samples are analyzed for polonium-210 and plutonium-238. The average concentrations of polonium-210, plutonium-238 and tritium oxide detected during 1971 at the onsite high volume air sampling station were 0.01 percent, 0.05 percent, and 0.07 percent of their respective AEC standards. The average concentration of polonium-210, plutonium-238 and tritium oxide detected during 1971 at the onsite low volume air sampling station located at the site center were 0.02 percent, 0.04 percent, and 2.7 percent of their respective AEC standards. These values for the other low volume air sampling station located at the northern perimeter were 0.01 percent, 0.03 percent, and 2.4 percent, respectively.

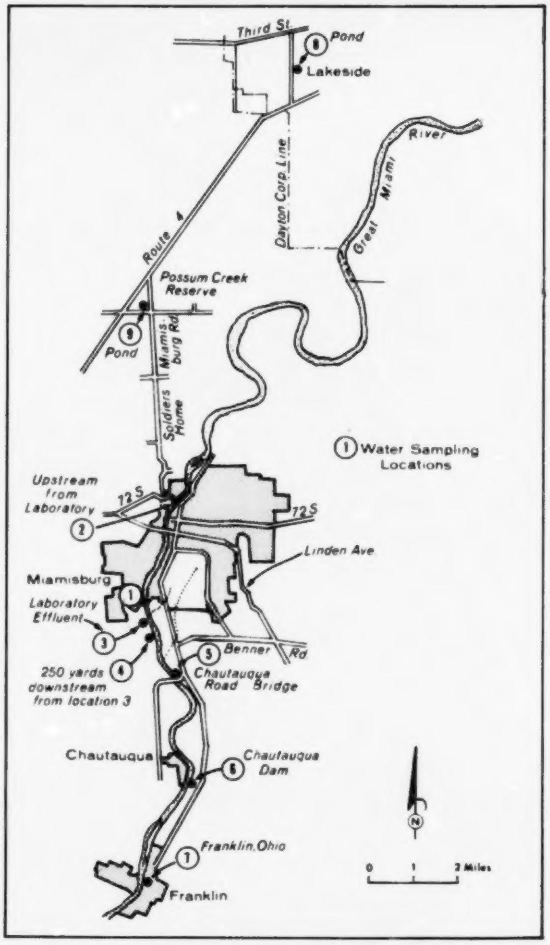

Figure 2. Water monitoring stations, Mound Laboratory

Water monitoring

During January through June 1971, water samples were collected twice per week along the bank of the Great Miami River and from two ponds northeast of the laboratory. Analysis of these samples is performed using equipment which is capable of detecting radioactivity far below the AEC standard. All samples are analyzed for polonium-210, plutonium-238, and tritium oxide. A sample of approximately 200 ml was taken at each of 9 sampling locations during January–June and a 500 ml sample was taken during July–December. These locations are shown in figure 2.

The highest average concentration of polonium-210 detected during January–June at any sampling location was 2.82 percent of the AEC standard. This was detected 230 meters downstream from the Mound Laboratory effluent. A number is reported in the table because a value was assigned to those samples which were determined to be below the detectable limit. The number assigned to those samples was arrived at by multiplying the lowest detectable limit for polonium by a fraction which was the number of samples above the limit divided by the total number of samples analyzed.

Analysis of data obtained from water samples taken during July–December 1971 indicates that the average concentrations of polonium-210 detected were less than 1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 2 percent of the AEC standard. These polonium-210 results are summarized in tables 9, 10, and 11.

Plutonium-238 concentrations measured at all locations were less than 1 percent of the AEC standard with the maximum being 0.26 percent of the AEC standard. This was detected 10 feet downstream from the point the Mound Laboratory effluent enters the Great Miami River (locations 3 in figure 2). The average concentrations found at the remainder of the Great Miami River locations downstream from the Mound Laboratory outfall were at approxi-

Table 9. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	50	1.09	0.55
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	.28	.14
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	5.33	2.67
230 meters downstream from Mound effluent (location 4)	50	5.65	2.82
Chautauqua Road Bridge (location 5)	50	.59	.29
Chautauqua Dam (location 6)	50	.45	.22
Franklin, Ohio (location 7)	50	.51	.25
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound (location 8)	50	.33	.17
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	.52	.26

[a] Lowest detectable limit for polonium in water is 1.28 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 10. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	0.7±0.4	0.3
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	.7± .4	.3
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	1.9± .6	.9
230 meters downstream from Mound effluent (location 4)	49	.7± .4	.3
Chautauqua Road Bridge (location 5)	49	.8± .4	.4
Chautauqua Dam (location 6)	49	.8± .4	.4
Franklin, Ohio (location 7)	48	.7± .4	.3
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	49	.7± .4	.3
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	.8± .4	.4

[a] Lowest detectable limit for polonium in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 11. Summary of offsite water monitoring for polonium–210, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	0.9±0.5	0.4
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	.5± .4	.2
Great Miami River, 3 meters downstream from Mound effluent (location 3)	99	3.6± .8	1.8
230 meters downstream from Mound effluent (location 4)	99	3.2± .7	1.6
Chautauqua Road Bridge (location 5)	99	.7± .4	.3
Chautauqua Dam (location 6)	99	.6± .4	.3
Franklin, Ohio (location 7)	98	.6± .4	.3
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	99	.5± .4	.2
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	83	.6± .4	.3

[a] Lowest detectable limit for polonium–210 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for polonium–210 is 200 pCi/liter.

Table 12. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	50	1.8	0.09
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	1.3	.07
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	5.2	.26
230 meters downstream from Mound effluent (location 4)	50	3.8	.19
Chautauqua Road Bridge (location 5)	50	1.5	.07
Chautauqua Dam (location 6)	50	1.4	.07
Franklin, Ohio (location 7)	50	1.8	.09
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	50	1.0	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	.8	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutonium–238 is 2 nCi/liter.

mately the same concentration level as found at the sampling location upstream from Mound Laboratory outfall (location 2 in figure 2). Average concentrations of plutonium–238 measured during July–December 1971 at all sampling locations were less than 0.1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 0.2 percent of the AEC standard. These results are summarized in tables 12–14.

The highest average concentration of tritium oxide for January–June was 4.74 percent of

Table 13. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	1.3 ±0.5	0.07
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	1.0 ± .5	.05
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	1.5 ± .5	.08
230 meters downstream from Mound effluent (location 4)	49	1.3 ± .5	.07
Chautauqua Road Bridge (location 5)	49	1.1 ± .5	.06
Chautauqua Dam (location 6)	49	1.0 ± .5	.05
Franklin, Ohio (location 7)	48	.8 ± .4	.04
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	49	.9 ± .5	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	.8 ± .4	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutonium–238 is 2 nCi/liter.

Table 14. Summary of offsite water monitoring for plutonium–238, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (pCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	1.5 ±0.5	0.08
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	1.1 ± .5	.06
Great Miami River, 3 meters downstream from Mound ML effluent (location 3)	99	3.4 ± .8	.17
230 meters downstream from Mound effluent (location 4)	99	2.5 ± .6	.13
Chautauqua Road Bridge (location 5)	99	1.3 ± .5	.07
Chautauqua Dam (location 6)	99	1.2 ± .5	.06
Franklin, Ohio (location 7)	98	1.2 ± .5	.06
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound (location 8)	99	1.0 ± .5	.05
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound (location 9)	83	.8 ± .4	.04

[a] Lowest detectable limit for plutonium–238 in water is 0.13 pCi/liter.
[b] The applicable AEC radiation protection standard for plutionium–238 is 2 nCi/liter.

the AEC standard, detected 10 feet downstream from the Mound Laboratory effluent. The next highest average concentration detected was 2.74 percent of the AEC standard, 250 yards downstream from the laboratory effluent. The average concentrations found at the remainder of the Miami River sampling locations downstream from the laboratory outfall were below the concentration detected upstream from the outfall. Analysis of the tritium oxide data obtained from these biweekly water samples during the second half of 1971 indicates that the average concentration was less than 1 percent of the AEC standard. The average concentrations for the entire year of 1971 were less than 2.8 percent of the AEC standard. These results are summarized in tables 15–17.
are summarized in tables 15–17.

Table 15. Summary of offsite water monitoring for tritium, Mound Laboratory environs, January-June 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	50	18.5	1.85
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	50	6.3	.63
Great Miami River, 3 meters downstream from Mound effluent (location 3)	50	47.4	4.74
230 meters downstream from Mound effluent (location 4)	50	27.4	2.74
Chautauqua Road Bridge (location 5)	50	4.8	.48
Chautauqua Dam (location 6)	50	3.0	.30
Franklin, Ohio (location 7)	50	3.0	.30
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	50	5.5	.55
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	50	9.0	.90

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.
[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Eight additional surface water locations such as ponds and streams are sampled monthly. A sample of approximately 4 liters is collected at each location and analyzed for polonium–210, plutonium–238, and tritium oxide. The average concentrations of polonium–210 measured at the surface water locations during 1971 were less than 0.1 percent of the AEC standard. The average concentrations of plutonium–238 measured at these locations during 1971 were less than 0.01 percent of the AEC standard. The average concentrations of tritium oxide meas-

Table 16. Summary of offsite water monitoring for tritium, Mound Laboratory environs, July-December 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	49	5.5±0.3	0.55
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	49	1.3± .2	.13
Great Miami River, 3 meters downstream from Mound effluent (location 3)	49	8.1± .4	.81
230 meters downstream from Mound effluent (location 4)	49	3.5± .3	.35
Chautauqua Road Bridge (location 5)	49	1.9± .2	.19
Chautauqua Dam (location 6)	49	1.7± .2	.17
Franklin, Ohio (location 7)	48	1.7± .2	.17
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	41	2.5± .2	.25
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	33	4.5± .3	.45

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.

[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Table 17. Summary of offsite water monitoring for tritium, Mound Laboratory environs, January-December 1971

Sample location	Number of samples	Average concentration[a] (nCi/liter)	Average as percent of AEC standard[b]
Great Miami River, 23 meters upstream from Mound effluent (location 1)	99	12.0±0.5	1.20
Sycamore Street Bridge, Miamisburg, Ohio (upstream, location 2)	99	3.8± .3	.38
Great Miami River, 3 meters downstream from Mound effluent (location 3)	99	27.9± .7	2.79
230 meters downstream from Mound effluent (location 4)	99	15.5± .6	1.55
Chautauqua Road Bridge (location 5)	99	3.3± .3	.33
Chautauqua Dam (location 6)	99	2.4± .2	.24
Franklin, Ohio (location 7)	98	2.3± .2	.23
Pond-opposite VA Hospital, Dayton, Ohio (13 km NE of Mound, location 8)	91	4.1± .3	.41
Pond-Possum Creek Reserve, Dayton, Ohio (10 km NE of Mound, location 9)	83	7.2± .4	.72

[a] Lowest detectable limit for tritium in water is 0.2 nCi/liter.

[b] The applicable AEC radiation protection standard for tritium is 1000 nCi/liter.

Table 18. Summary of surface water monitoring, January-December 1971

Location	Average concentration polonium-210 (pCi/liter)	Percent of AEC standard[a]	Average concentration plutonium-238 (pCi/liter)	Percent of AEC standard[b]	Average concentration tritium (nCi/liter)	Percent of AEC standard[c]
10	0.11±0.017	0.05	0.04±0.0034	0.002	2.7±0.10	0.27
11	.09± .015	.05	.11± .0056	.005	4.2± .13	.42
12	.13± .018	.07	.01± .0017	.001	2.5± .10	.25
13	.05± .011	.03	.05± .0037	.003	1.8± .08	.18
14	.11± .017	.05	.07± .0045	.003	8.6± .18	.86
15	.11± .017	.05	.10± .0053	.005	6.3± .15	.63
16	.13± .018	.07	.05± .0037	.003	3.1± .11	.31
17	.22± .023	.11	.21± .0077	.010	7.1± .16	.71

[a] AEC standard for polonium-210 in water is 200 pCi/liter. Lowest detectable limit for polonium-210 in water is 0.03 pCi/liter.

[b] AEC standard for plutonium-238 in water is 2000 pCi/liter. Lowest detectable limit for plutonium-238 in water is 0.04 pCi/liter.

[c] AEC standard for tritium in water is 1000 nCi/liter. Lowest detectable limit for tritium in water is 0.4 nCi/liter.

ured at these locations were less than 0.9 percent of the AEC standard. These results are presented in table 18.

Drinking water from communities in the surrounding area is sampled quarterly. These communities are shown in figure 1. A sample of approximately 4 liters is collected and analyzed for polonium-210, plutonium-238, and tritium oxide. The concentrations of polonium-210, plutonium-238, and tritium oxide were found to be less than 0.05 percent, 0.01 percent, and 2 percent of their AEC standards, respectively. The results of the community drinking water sampling program are summarized in table 19.

Food and vegetation

Various locally grown food and vegetation samples are collected from the surrounding area. The samples collected include milk, eggs, garden vegetables, grass, and aquatic life. The intent of this portion of the environmental monitoring program is to determine if there is any uptake and concentration of radionuclides by plant or animal life. The polonium-210 and plutonium-238 content of the foodstuff and vegetation samples is determined by slowly evaporating the sample to dryness and then proceeding with the same techniques used for

Table 19. Summary of community drinking water, Mound Laboratory environs, 1971

Location	Average concentration polonium-210 (pCi/liter)	Percent of AEC standard[a]	Average concentration plutonium-238 (pCi/liter)	Percent of AEC standard[b]	Average concentration tritium (nCi/liter)	Percent of AEC standard[c]
Bellbrook	<0.02 ±0.007	<0.01	0.02 ±0.008	0.001	1.3 ±0.034	0.13
Camden	<.02 ± .007	<.01	.05 ± .012	.003	.9 ± .028	.09
Centerville	<.02 ± .007	<.01	.04 ± .011	.002	1.5 ± .037	.15
Dayton	.05 ± .011	.03	.02 ± .008	.001	.3 ± .016	.03
Eaton	.04 ± .010	.02	.02 ± .008	.001	1.8 ± .040	.18
Franklin	.03 ± .008	.01	.02 ± .008	.001	1.1 ± .031	.11
Germantown	<.02 ± .007	<.01	.04 ± .011	.002	1.9 ± .041	.19
Kettering	<.02 ± .007	<.01	.02 ± .008	.001	.6 ± .023	.06
Lebanon	<.02 ± .007	<.01	.04 ± .011	.002	.3 ± .016	.03
Mason	<.02 ± .007	<.01	.02 ± .008	.001	<.3 ± .016	<.03
Miamisburg	.04 ± .010	.02	.25 ± .028	.013	19.7 ± .138	1.97
Middletown	<.02 ± .007	<.01	.02 ± .008	.001	1.0 ± .030	.10
Moraine	<.02 ± .007	<.01	NA		2.8 ± .050	.28
Springboro	<.02 ± .007	<.01	NA		2.8 ± .050	.28
Waynesville	<.02 ± .007	<.01	NA		4.3 ± .062	.43
West Carrollton	.03 ± .008	.01	.02 ± .008	.001	1.0 ± .030	.10

[a] The applicable AEC radiation protection standard for polonium-210 in water is 200 pCi/liter. Lowest detectable limit for polonium-210 in drinking water is 0.017 pCi/liter.

[b] The applicable AEC radiation protection standard for plutonium-238 in water is 2 000 pCi/liter. Lowest detectable limit for plutonium-238 in drinking water is 0.018 pCi/liter.

[c] The applicable AEC radiation protection standard for tritium in water is 1 000 nCi/liter. Lowest detectable limit for tritium oxide is 0.26 nCi/liter.

NA, no analysis.

Table 20. Summary of foodstuffs and vegetation analysis for 1971 Mound Laboratory environs

Type of sample	Average concentration polonium-210 (fCi/g)	Percent of AEC standard[a]	Average concentration plutonium-238 (fCi/g)	Percent of AEC standard[b]	Average concentration tritium (pCi/g)	Percent of AEC standard[c]
Milk	2.79	1.4	0.14	0.007	2.4	0.24
Eggs	NA		.31	.015	NA	
Vegetables	.78	.39	.31	.015	NA	
Grass	14.62	7.3	1.65	.083	NA	
Aquatic life	15.40	7.7	2.4	.12	NA	

[a] The applicable AEC radiation protection standard for plutonium-210 is 200 fCi/g.

[b] The applicable AEC radiation protection standard for plutonium-238 is 2000 fCi/g.

[c] The applicable AEC radiation protection standard for tritium is 1000 pCi/g.

NA, no analysis.

polonium-210 and plutonium-238 analyses of air samples. These samples are analyzed for tritium oxide by distilling the water fraction from an aliquot of the entire sample. The tritium content of the distillate is then determined in the same manner as the water samples previously discussed in this report. The results of the foodstuff and vegetation analyses are summarized in table 20. The concentration is given in terms of the sample weight before evaporation to dryness. The only foodstuff samples analyzed for tritium are milk. Rosenthal and Stewart (*3*) in their study on tritium transfer in simple aquatic food chains concluded that equilibrium between tritium in aquatic life and its environment is rapid and that a biological sink does not exist. Therefore, if the environment, i.e., air and water, were monitored, the levels found there would be indicative of the levels present in the plant and animal life growing therein. However, in addition to monitoring air and water for tritium, milk also is analyzed for tritium content since it is consumed in relatively large quantities by young children and babies. The vegetables analyzed included green beans, onions, corn, and tomatoes. The samples of aquatic life analyzed included only the edible fleshy portions. There appears to be a very small amount of polonium-210 in the aquatic life samples. Since the foodstuff sampling program has been in operation for only slightly more than a year and polonium-210 does appear naturally in the earth's crust, no conclusions can be drawn. More data must be accumulated before any conclusion can be reached as to the

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source of the polonium-210 found in these types of samples. No other indication has been found that there is any significant uptake and concentration by plant or animal life of the three radionuclides handled at Mound Laboratory.

Soil and silt

Two types of soil samples from areas surrounding the laboratory have been analyzed for plutonium-238. One type of sample is used to evaluate the resuspendible amounts of plutonium-238 in the soil surrounding Mound Laboratory. Surface scrapings (approximately ⅛ inch deep) of undisturbed soil were collected for this evaluation. Surface scraping samples were taken from 20 sectors surrounding Mound Laboratory to a distance of 10 miles. These sectors are shown in figure 3. In addition, surface scrapings were taken 50 miles northeast, southwest, and northwest of the laboratory to serve as background control samples. Twenty-five scrapings are composited to form a sample for each sector. Soil samples are digested with an acid mixture to extract the plutonium. The solution is then passed over in ion exchange column specific for plutonium and analyzed in the same manner as the particulate air samples. This leach method has been compared with a fusion method for soil analysis (*4*), and good agreement was obtained. The leach method was chosen for the soil analysis because larger samples, which minimize sampling and aliquoting errors and increase sensitivity, can be handled with this method.

The results of the soil surface scraping study

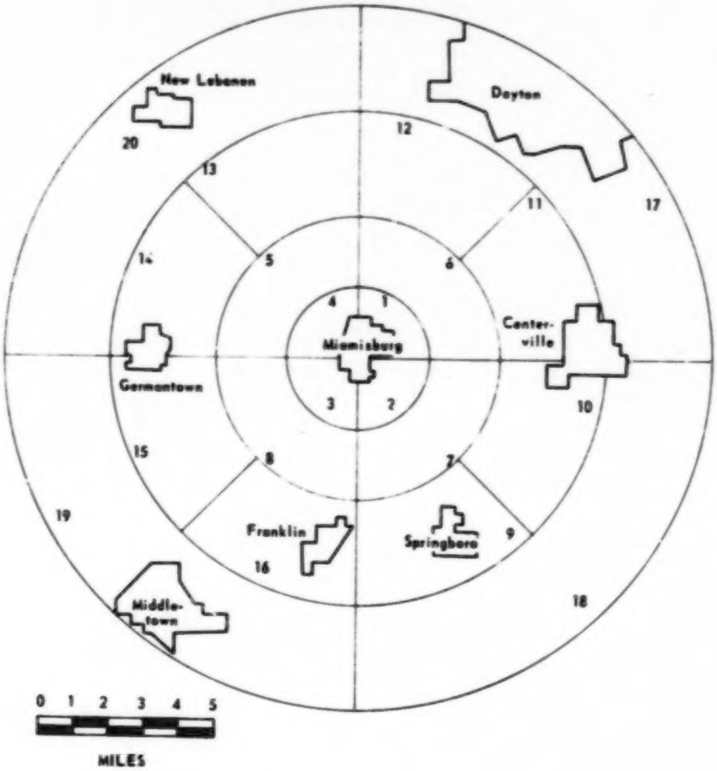

Figure 3. Soil sampling sectors, Mound Laboratory

Table 21. Resuspendible plutonium–238 levels determined from ⅛ inch soil surface scrapings, Mound Laboratory environs, January-December 1971

Sector	Plutonium–238 (dpm/cm²)[a]
1	0.118 ± 0.0065
2	.013 ± .0021
3	.174 ± .0078
4	.025 ± .0029
5	.003 ± .0010
6	.008 ± .0017
7	.004 ± .0012
8	.006 ± .0015
9	.003 ± .0010
10	.003 ± .0010
11	.001 ± .0005
12	.002 ± .0008
13	.004 ± .0012
14	.004 ± .0012
15	.003 ± .0010
16	.037 ± .0036
17	.004 ± .0012
18	.003 ± .0010
19	.003 ± .0010
20	.001 ± .0005
50 miles -NE[b]	.002 ± .0008
50 miles -SE[b]	.002 ± .0008
50 miles -SW[b]	.003 ± .0010
50 miles -NW[b]	.001 ± .0005
Reagent blanks	<0.001 – 0.003

[a] dpm/cm² = disintegration per minute per square centimeter of sample surface.

[b] Mound Laboratory background control data scrapings were taken at 50 miles.

[c] Lowest detectable limit for plutonium–238 in soil surface scrapings is 0.0004 dpm/cm².

for 1971 are shown in table 21. The highest concentration of plutonium–238 found in 1971 was approximately 2 percent of the most restrictive levels suggested by Kathren (*5*) for urban areas.

The second type of sample is used to determine the inventory amounts of plutonium–238 in the soil surrounding Mound Laboratory. A 3.5-inch diameter core of soil approximately 1.5 inches deep is taken for this determination. The site selection and sampling techniques used in core sampling basically were those suggested by the criteria given for "Soil Sampling for Plutonium Analysis" as distributed by the AEC Division of Operational Safety. Core samples were collected from various locations within approximately 1 mile from the laboratory. Five cores were collected from a 20-foot square area at each location and composited to form one core sample. Additional core samples for background control data were taken from locations 50 miles from the laboratory. The background control core samples consisted of 20 cores, 4 cores from each of 5 locations. The results of the core sampling program are summarized in table 22. The sectors referred to are those shown on figure 3. No standards have been established for radioactive species in soil. Additional sample analyses are necessary before a total inventory can be calculated and these are continuing as part of the Mound Laboratory's comprehensive Environmental Control Program.

Silt samples are collected quarterly from four locations on the Great Miami River. These samples are taken at four of the same locations that water samples are taken from and are identified by the same number shown in figure 2. Additional silt samples are collected annually from the same surface water locations which are sampled monthly. The silt samples are analyzed in the same manner as the soil samples. The results of Great Miami River silt sampling for 1971 are summarized in table 23.

Table 22. Plutonium–238 results in soil samples at core locations Mound Laboratory environs, January-December 1971

Sector	Plutonium–238[a]	
	(dpm/g)[b]	(dpm/cm²)[c]
1	4.68 ± 0.03	16.31 ± 0.10
2	2.19 ± .02	6.31 ± .06
3	.07 ± .004	.30 ± .01
4	.12 ± .005	.46 ± .02
Irwin, Ohio (Northeast–50 miles)	.005 ± .001	.016 ± .003
Sardinia, Ohio (Southeast–50 miles)	.005 ± .001	.014 ± .003
Aurora, Indiana (Southwest–50 miles)	.003 ± .001	.008 ± .002
Winchester Indiana (Northwest–50 miles)	.003 ± .001	.010 ± .002
Reagent blanks	<.001 ± .001	.002 ± .001

[a] The levels of plutonium in soil as a result of nuclear testing fallout reported by Health and Safety Laboratory for the southern Ohio area range from 0.248 to 0.416 dpm/cm².

[b] dpm/g = disintegration per minute per gram of sample.

[c] dpm/cm² = disintegration per minute per square centimeter of sample surface.

Lowest detectable limit for plutonium–238 in soil core samples is 0.0003 dpm/g or 0.0008 dpm/cm².

Table 23. Summary of Great Miami River silt samples for 1971, Mound Laboratory environs

Location	Plutonium-238 (dpm/g)*
2	0.431 ±0.021
4	.408 ±0.021
6	.947 ±0.032
7	.865 ±0.030

* dpm/g = disintegration per minute per gram of sample.
Lowest detectable limit for plutonium-238 in silt samples is 0.001 dpm/g.

The results of the silt sampling from the area ponds are summarized in table 24. There appears to be a very slight accumulation of plutonium-238 in river silt from the very small amounts of plutonium-238 which are discharged to the river. However, as mentioned previously, there does not appear to be any reentrainment of plutonium-238 by plant or animal life in the river nor by the river itself. No significant accumulation is indicated, however, by the pond silt data. There are no standards for radioactive species in silt.

Table 24. Summary of pond silt samples for 1971 Mound Laboratory environs

Location	Plutonium-238 (dpm/g)*
10	0.017 ±0.004
11	.027 ± .005
12	.023 ± .005
13	.062 ± .008
14	.017 ± .004
15	.011 ± .003
16	.012 ± .004
17	.038 ± .006

* dpm/g = disintegration per minute per gram of sample.
Lowest detectable limit for plutonium-238 in silt samples is 0.001 dpm/g.

Summary

The average concentrations of polonium-210, plutonium-238, and tritium detected in the environment surrounding Mound Laboratory, Miamisburg, Ohio, are presented for January–December 1971. The average concentrations of these radioisotopes were well within the standards adopted by the Atomic Energy Commission.

Atmospheric monitoring for radioactive species found the highest average concentrations of plutonium and tritium in air during 1971 to be 1 percent and 4 percent of their respective AEC standards. These concentrations are 10 percent and 26 percent lower, respectively, than those detected during 1970. The average concentrations of polonium in air detected during 1971 were approximately 0.2 percent of the AEC standard which is approximately the same as detected during 1970.

Water monitoring for radioactive species found the highest average concentration of plutonium at any of the water sampling locations during 1971 to be only 0.2 percent of the AEC standard which is 40 percent of the highest average concentration reported during 1970. The highest average concentrations of polonium and tritium in water during 1971 were 1.8 percent and 2.8 percent of their respective AEC standards. These concentrations are approximately the same as reported during 1970.

Additionally, data concerning radioactive species in surface water, community drinking water, foodstuffs and silt are presented for the first time. No significant uptake of radioactive species from air or water by plant or animal life has been observed. No reentrainment of radioactive species from soil or silt is indicated at this time. The highest level of plutonium-238 found during 1971 in soil surface scrapings was approximately 2 percent of the most restrictive levels suggested for urban areas. Soil core sample analyses will continue to establish a plutonium soil inventory as part of the total program to assess the impact of the laboratory's operations on the environment.

These data indicate that the operation of the laboratory has had a negligible effect on the environment.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1970	March 1973

REFERENCES

(*1*) STATE OF OHIO, ECONOMIC RESEARCH DIVISION. Statistical abstract of Ohio (March 1969) p. 6.

(*2*) U.S. DEPARTMENT OF HEALTH, EDUCATION, and WELFARE. Report for consultation on the metropolitan Dayton intrastate air quality control region. Consumer Protection and Environmental Health Service, National Air Pollution Control Administration (September 1969), p. 11.

(*3*) ROSENTHAL, Jr., G. M. and M. L. STEWART. Tritium incorporation in algae and transfer in simple aquatic food chains, CONF-710501-24. Presented at Symposium on Radioecology, Oak Ridge, Tenn., May 10-12, 1971.

(*4*) BISHOP, C. T., W. E. SHEEHAN, R. K. GILLETTE, and B. ROBINSON. Comparison of a leaching method and a fusion method for the determination and measurement of plutonium in the environment, LA-4756. Proceedings of Environmental Plutonium Symposium, Los Alamos, New Mex., August 4-5, 1971.

(*5*) KATHREN, R. L. Towards interim acceptable surface contamination levels for environmental PuO_2, BNWL-SA-1510. Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash. (March 14, 1968), p. 10.

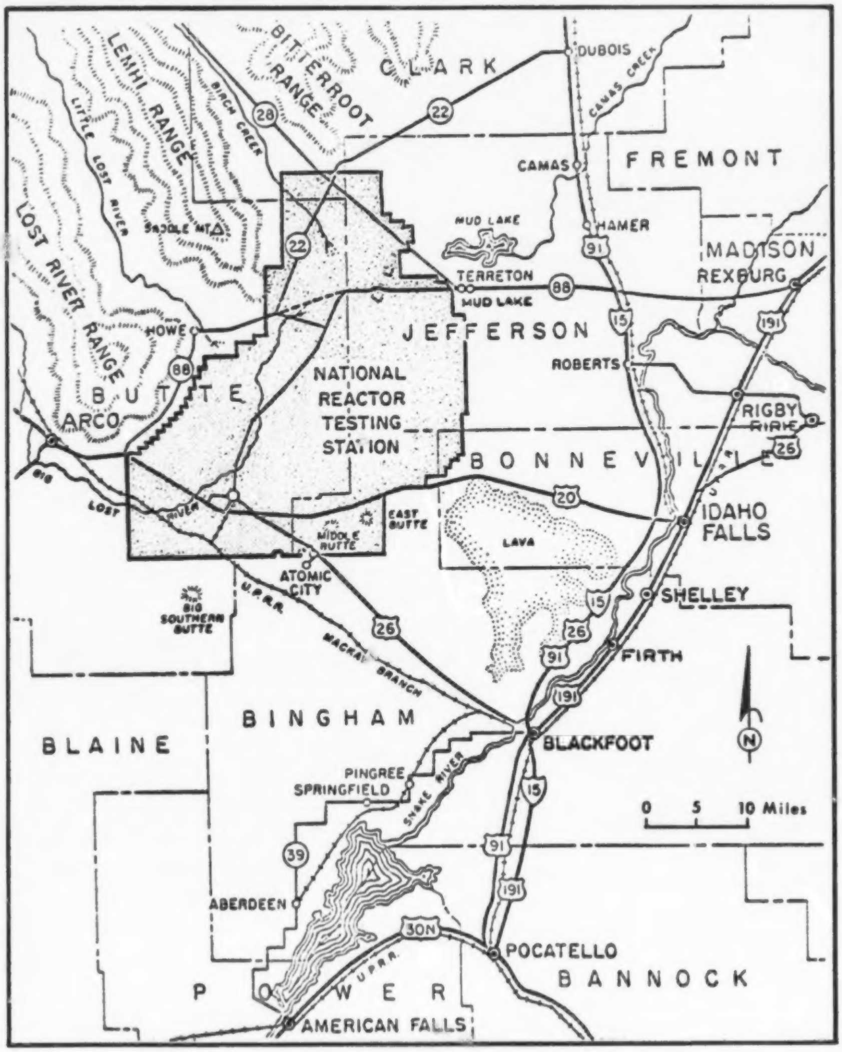

Figure 4. National Reactor Testing Station environs

2. National Reactor Testing Station[3]
January–December 1971

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) was established in 1949 by the U.S. Atomic Energy Commission (AEC) to promote reactor development by building, testing, and operating various types of nuclear reactors, allied plants, and equipment. By 1971, 49 reactors had been built at the NRTS and 16 were still operating or operable.

The NRTS is situated on a desert plain in southeastern Idaho at an average elevation of 4865 feet. The station is comprised of 571 800 acres of sagebrush and basalt fields and the boundary stretches 39 miles from north to south and about 36 miles wide in its broader southern part. The nearest NRTS boundaries are 29 miles west of Idaho Falls, 32 miles northwest of Blackfoot, 50 miles northwest of Pocatello, and 7 miles southeast of Arco, Idaho (figure 4).

Although annual precipitation in the NRTS area has averaged only 8.5 inches, underlying the desert plain is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about one billion gallons per day. Aquifer water is supplied principally from the North Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. The underground water seeps slowly at a rate of 10–20 feet per day to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho.

Major programs currently underway at the NRTS fall into five major categories. One program provides test irradiation services from the two operating high-flux test reactors, the ETR and ATR. Another program operates the Idaho Chemical Processing Plant (ICPP) for recovery of uranium from highly enriched spent fuels. A third major program is that of light-water-cooled reactor safety testing and research. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are the important projects in the reactor safety program. Other significant programs include the operation of the Experimental Breeder Reactor II (EBR–II) by Argonne National Laboratory and the operation of the Naval Reactor Facility (NRF).

Because of these activities, small amounts of radioactivity were released to the atmosphere and the Snake River Plain aquifer. In its environmental monitoring program, the Health Services Laboratory (HSL) of the AEC measured the levels of radioactivity in air and ground water samples and measured the gamma radiation exposure at onsite locations, communities near the NRTS boundary, and distant background locations. The concentration of suspended airborne particulates and dust fall rates also were measured.

Air monitoring

Air samplers were operated continuously and drew air through sets of filters for weekly periods. A membrane prefilter (Gelman Model AN–8000) for collection of particulates was followed by an in-line activated charcoal-impregnated cellulose fiber filter (Gelman Model AC–1) for removal of radioiodine from the air stream. An average air flow of approximately 1 cubic foot per minute (cfm) was maintained. Air samplers were located onsite, in the small communities close to the NRTS perimeter, and at distant background sites (figure 5). These locations provided comprehensive surveillance of atmospheric radioactivity and theoretically made it possible to differentiate worldwide fallout from NRTS releases.

The filters were analyzed 5 days after the end of each sampling period to allow for decay of short-lived natural radioactivity. Gross alpha and beta analyses were performed on the membrane filters and gross beta analyses alone were performed on the charcoal filters. Activity de-

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[3] Summarized from "National Reactor Testing Station Environmental Monitoring Program Report, January–December 1971," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory.

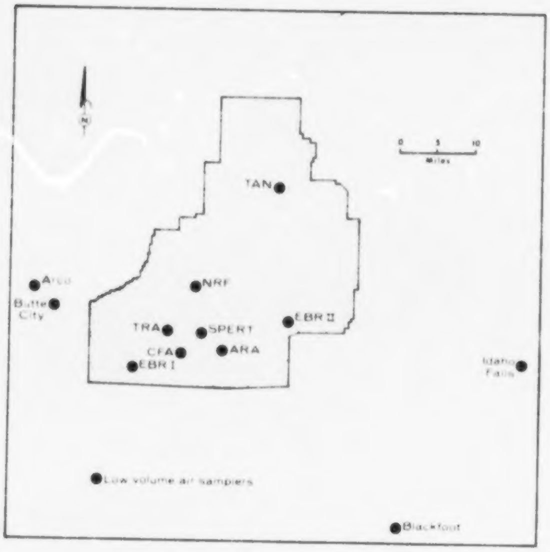

Figure 5. Onsite and offsite air sampling locations, National Reactor Testing Station

tected on the charcoal filters was assumed to be iodine–131. Gross alpha activity was determined by a technique reported by Hallden and Harley (*6*). Using this method an alpha-sensitive phosphor disc was placed in direct contact with the filter and counted with a low-noise photomultiplier tube. For gross beta analyses, the filters were mounted on a ringed planchet and counted in a low background beta counter. At the end of each calendar quarter, the particulate filters from selected locations were composited and the concentrations of gamma-emitting radionuclides determined by gamma spectrometry. A strontium–90 analysis also was performed on the quarterly composites. Each membrane filter was dried and weighed before and after use to determine the average airborne particulate concentrations during the sampling period.

Onsite air samples were collected at locations close to the sources of released radioactivity and were expected to have the highest concentrations. Background samples were collected at Idaho Falls, Blackfoot, and Pocatello. These locations were sufficiently remote to ensure that any radioactivity detected was due to natural background or sources other than NRTS operations. Levels of radioactivity in onsite and boundary community (Arco, Butte City, Howe, and Mud Lake) air samples were compared to levels in the background samples. If the radioactivity levels were found to be significantly higher than background, the net amount above background was assumed to be radioactivity introduced to the environment from NRTS operations. The net concentrations of radioactivity then were compared to the AEC standards set forth in the U.S. Atomic Energy Commission's Manual Chapter 0524 (AECM 0524). The air sampling data are presented in table 25.

The gross alpha air concentrations at the background locations of Idaho Falls, Blackfoot, and Pocatello were not representative of the NRTS background levels. This was due to higher airborne concentrations of naturally occurring radioactivity in the upper Snake River Valley. Therefore, the onsite gross alpha concentrations and the gross alpha concentrations at the NRTS boundary communities were not compared to an average background concentration. However, if measurable onsite releases of alpha activity were occurring, it would have been expected that the gross alpha concentrations at onsite locations would be higher than at the communities near the NRTS boundary. This pattern was not observed and indicates the gross alpha concentrations measured at the NRTS and boundary community locations were the result of natural background radioactivity.

All the gross beta (iodine–131) concentrations determined from the charcoal filters were near or below the detection limit of the analysis. For 1971, the average gross beta concentration of particulates at onsite locations was 0.65 pCi/m^3 and the highest individual average was 0.82 pCi/m^3, occurring at the CFA location. The yearly average background gross beta concentration was 0.53 pCi/m^3. The difference between the average onsite and offsite gross beta concentration was largely the result of releases of small quantities of radioactivity from the Idaho Chemical Processing Plant. Fission and activation products identified on the onsite particulate filters were cerium-praseodymium–144, antimony–125, cesium–134, cesium–137, ruthenium-rhodium–106, ruthenium–103, zir-

Table 25. Radioactivity in air, National Reactor Testing Station, January-December 1971

Sampling locations	Number of samples	Type of analysis and filter	Minimum detectable concentration (fCi/m³)	Maximum single sample concentration (fCi/m³)	Average sample concentration (fCi/m³)	Average background concentration, if applicable (fCi/m³)	Maximum average net concentration (fCi/m³)	AEC standard (fCi/m³)
Onsite (8 locations)	416	Gross α —Membrane	1	19	1.7	—	1.7	6 000
		Gross β —Membrane	10	3 200	650	530	120	[a] 30 000
		Gross β —Charcoal	10	270	<10	<10	<10	9×10^6
EBR-I (onsite)	52	^{144}Ce-Pr —Membrane	—	—	160	<140	<160	6×10^6
		^{125}Sb —Membrane	—	—	<22	<7.0	<22	3×10^7
		^{134}Cs —Membrane	—	—	<8.9	<1.4	<8.9	4×10^7
		^{137}Cs —Membrane	—	—	<85	<9.6	<35	1×10^7
		^{106}Ru-Rh—Membrane	—	—	43	<28	<43	6×10^6
		^{103}Ru —Membrane	—	—	9.8	<14	<9.8	8×10^7
		^{95}Zr —Membrane	—	—	<47	<35	<47	3×10^7
		^{95}Nb —Membrane	—	—	71	57	14	1×10^8
		^{141}Ce —Membrane	—	—	<8.3	<11	<8.3	2×10^8
		^{90}Sr —Membrane	—	—	18	<4.7	<18	6×10^6
Arco (offsite)	52	Gross α —Membrane	1	4.7	1.7	—	1.7	20
		Gross β —Membrane	10	1 600	500	530	—	[a] 1 000
		Gross β —Charcoal	10	36	<10	<10	<10	1×10^5
Howe (offsite)	52	Gross α —Membrane	1	4.5	1.9	<	1.9	20
		Gross β —Membrane	10	1 700	630	530	100	[a] 1 000
		Gross β —Charcoal	10	50	<10	<10	<10	1×10^5
Butte City (offsite)	52	Gross α —Membrane	1	3.3	1.5	—	1.5	20
		Gross β —Membrane	10	2 100	620	530	90	[a] 1 000
		Gross β —Charcoal	10	51	<10	<10	<10	1×10^5
		^{144}Ce-Pr —Membrane	—	—	110	<140	<110	2×10^5
		^{125}Sb —Membrane	—	—	<8.4	<7.0	<8.4	9×10^5
		^{103}Ru —Membrane	—	—	11	<14	<11	3×10^7
		^{106}Ru-Rh—Membrane	—	—	<24	<28	<24	2×10^5
		^{134}Cs —Membrane	—	—	<2.8	<1.4	<2.8	4×10^5
		^{137}Cs —Membrane	—	—	9.7	<9.6	<9.7	5×10^5
		^{95}Zr —Membrane	—	—	<36	<35	<36	1×10^6
		^{95}Nb —Membrane	—	—	63	57	6	3×10^6
		^{141}Ce —Membrane	—	—	<7.7	<11	<7.7	5×10^6
		^{90}Sr —Membrane	—	—	4.7	<4.7	<4.7	30 000
Mud Lake (offsite)	52	Gross α —Membrane	1	3.3	1.5	—	1.5	20
		Gross β —Membrane	10	1 900	620	530	90	[a] 1 000
		Gross β —Charcoal	10	26	<10	<10	<10	1×10^5
		^{144}Ce-Pr —Membrane	—	—	<180	<140	<180	2×10^5
		^{125}Sb —Membrane	—	—	<16	<7.0	<16	9×10^5
		^{103}Ru —Membrane	—	—	<17	<14	<17	3×10^6
		^{106}Ru-Rh—Membrane	—	—	<42	<28	<42	2×10^5
		^{134}Cs —Membrane	—	—	<6.4	<1.4	<6.4	4×10^5
		^{137}Cs —Membrane	—	—	15	<9.6	<15	5×10^5
		^{95}Zr —Membrane	—	—	<49	<35	<49	1×10^6
		^{95}Nb —Membrane	—	—	74	57	17	3×10^6
		^{141}Ce —Membrane	—	—	<11	<11	<11	5×10^6
		^{90}Sr —Membrane	—	—	13	<4.7	<13	30 000

[a] Assumes actinium-227 not present.

conium-95, niobium-95, cerium-141, and strontium-90. The same radionuclides were also identified on the background air filters, though generally in smaller concentrations. None of the concentrations of radionuclides identified on the onsite filters exceeded 0.002 percent of the corresponding AEC standards.

The air concentrations are mainly due to worldwide nuclear test fallout activity. An increase in the onsite and boundary community average above worldwide fallout levels such as occurred late in 1970 and the first half of 1971 are the result of atmospheric releases from the NRTS.

At the boundary community air sampling locations of Butte City, Mud Lake, Howe, and the offsite sampling locations closest to the NRTS, it was found that the average gross beta concentrations were slightly above the worldwide fallout level. The highest offsite yearly average net gross beta concentration of 0.10 pCi/m³ which occurred at Howe was only 10 percent of the appropriate concentration guide. The same radionuclides identified in the onsite samples were also found at the boundary community locations, although generally in smaller concentrations. None of the concentrations of radionuclides identified on the boundary community filters exceeded 0.09 percent of the concentration guide.

Water monitoring

Water samples were collected from onsite and

Table 26. Radioactivity in well water samples, National Reactor Testing Station, January-December 1971

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration (pCi/liter)	Maximum average net concentration (pCi/liter)
EBR-1 (1 well)	8	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
CFA (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	[c]140	[c]2	[c]99	(b)	[c]99
TRA (3 wells)	104	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	10	5	<5.1	(b)	<5.1
		Tritium	(b)	[c]2	(b)	(b)	(b)
CPP (2 wells)	45	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	72	5	<8.7	(b)	<8.7
		Tritium	[c]9.0	[c]2	[c]<4.7	(b)	[c]<4.7
		Strontium-90	28	1	4.6	—	4.6
NRF (3 wells)	63	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	6.8	5	<5.0	(b)	<5.0
		Tritium	(b)	[c]2	(b)	(b)	(b)
TAN (6 wells)	129	Gross alpha	4	3	<3.0	(b)	<3.0
		Gross beta	12	5	<5.1	(b)	<5.1
		Tritium	(b)	[c]2	(b)	(b)	(b)
SPERT-PBF (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	8	5	<5.2	(b)	<5.2
		Tritium	(b)	[c]2	(b)	(b)	(b)
ARA (2 wells)	52	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
EDF (1 well)	9	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
EBR-II (2 wells)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
Fire Station No. 2 (1 well)	26	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)

[a] AEC standards—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter, and strontium-90, 300 pCi/liter.
[b] Below detection limit.
[c] Concentration of tritium in nCi/liter.

Table 27. Radioactivity in offsite drinking water and surface water samples, National Reactor Testing Station January-December 1971

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration, if applicable (pCi/liter)	Maximum average net concentration (pCi/liter)
Drinking water, from Arco, Carey, Aberdeen, Dietrich, Atomic City, and Minidoka	12	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
Snake River at Bliss, Idaho	2	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)

[a] AEC standard—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter.
[b] Below detection limits.
[c] Concentration of tritium in nCi/liter.

offsite drinking water production wells and from the Snake River. Offsite and onsite water sampling locations can be seen in figures 6 and 7, respectively. All offsite samples were collected biannually; onsite samples were generally collected every 2 weeks. Gross alpha, gross beta, and tritium analyses routinely were performed on the water samples. For gross alpha analysis, an aliquot of the sample was evaporated on a stainless-steel planchet and counted with a scintillation counter using a technique similar to that described for the gross alpha analysis for the air filters. Another aliquot was evaporated and counted for gross beta activity in a low background beta counter. Tritium concentrations were determined with a Beckman Liquid Scintillation System. Water sampling data are presented in tables 26 and 27. Samples collected from Mud Lake, Monteview, Reno Ranch, Idaho Falls, and Roberts (all upgradient

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in the aquifer from the NRTS) were used to determine the background concentrations of radioactivity.

None of the offsite water samples collected during 1971 contained concentrations of radioactivity above the detection limits of the analyses. Only a few onsite samples contained gross alpha concentrations above the detection limit of 3 pCi/liter. Of the wells used for drinking purposes, the highest average beta concentration, 72 pCi/liter, was found in well number 2 at the Idaho Chemical Processing Plant. The 1971 average strontium-90 concentration at the ICPP was 4.6 pCi/liter. This strontium-90 concentration is less than 2 percent of the AECM 0524 standard. The highest 1971 average tritium concentration, 99 nCi/liter, was found at the Central Facilities Area (CFA) and was 3.3 percent of the AECM 0524 standard.

Food monitoring

Milk was the main foodstuff sampled. A composite grade A sample was collected from farm areas to the north and south of Idaho Falls each week. Monthly grade B milk samples were collected from dairies and individual farms in rural areas surrounding the NRTS. Analysis by gamma spectrometry for iodine-131 and cesium-137 was performed on all milk samples. Biannually the samples were analyzed for strontium-90. Wheat samples were collected from individual farms and grain elevators during the fall harvest and analyzed for gamma-emitting radionuclides by gamma spectrometry and for strontium-90. See figure 6 for the milk and wheat sampling locations.

All milk sampling results summarized in table 28 were compared to standards recommended by the Federal Radiation Council, since the AECM 0524 does not list concentration guides for milk. During 1971, the concentrations of iodine-131 and cesium-137 in milk were near or below the detection limits of the analysis. Strontium-90 concentrations in milk were less than 3 percent of the standard and were attributed to worldwide fallout, not NRTS operations. Only strontium-90 activity was detected in the wheat samples with the hull containing 90 percent of the total. This means only 10 percent of the activity will remain after the wheat is processed for use in food products. The strontium-90 in wheat is also attributed to worldwide fallout. Wheat sampling results are shown in table 29.

Table 28. Radionuclide concentrations in milk, National Reactor Testing Station January-December 1971

Location and sampling frequency	Analysis	Maximum single sample concentration (pCi/liter)	Average concentration[a] (pCi/liter)
Idaho Falls (weekly)	Iodine-131	21	<20
	Cesium-137	34	<30
	Strontium-90[b]	3.2	2.7
Minidoka (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	2.9	<2.4
Dietrich (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	5.5	4.2
Carey (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	6	4.2
Mud Lake (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	3.3	2.5
Reno Ranch (monthly)	Iodine-131	(c)	(c)
	Cesium-137	31	30
	Strontium-90[b]	2.9	2.4
Tabor (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	1.6	1.5
Howe (monthly)	Iodine-131	23	<20
	Cesium-137	(c)	(c)
	Strontium-90[b]	3.8	3.1
Arco (monthly)	Iodine-131	22	<20
	Cesium-137	(c)	(c)
	Strontium-90[b]	5.2	3.7
Firth and New Sweden (near Idaho Falls) (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	4.2	2.9
Lake and Riverside (Tabor-Blackfoot-Aberdeen area) (monthly)	Iodine-131	(c)	(c)
	Cesium-137	(c)	(c)
	Strontium-90[b]	4.0	3.3

[a] Federal Radiation Council standard: iodine-131, 100 pCi/liter; cesium-137, 3600 pCi/liter; strontium-90, 200 pCi/liter. Minimum detectable concentration: iodine-131, 20 pCi/liter; cesium-137, 30 pCi/liter; strontium-90, 1 pCi/liter.

[b] Only two samples during the year analyzed for strontium-90 activity.

[c] Below detection limits.

Table 29. Strontium-90 concentrations in wheat NRTS, January-December 1971

Sampling location	Strontium-90 concentration (pCi/g)
Monteview	0.014
Idaho Falls	.020
Blackfoot	.019
American Falls	.013
Minidoka	.019
Dietrich	.010
Carey	.017
Arco	.011

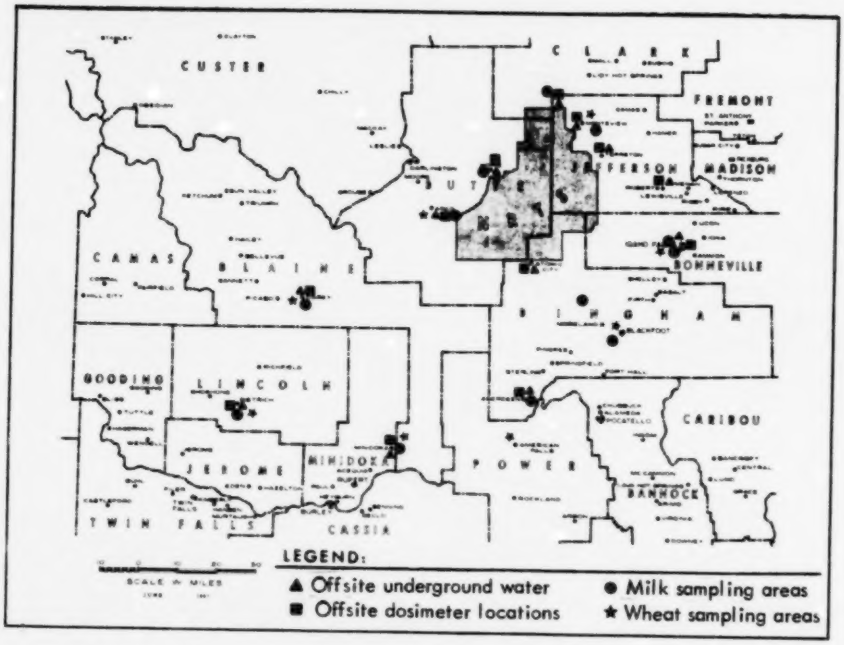

Figure 6. Environmental monitoring program, National Reactor Testing Station

Gamma radiation exposure

Environmental gamma radiation exposures were measured with thermoluminescent dosimeters (TLD's) placed at background and NRTS boundary community locations. Exposures at the distant locations of Idaho Falls, Blackfoot, Dietrich, Carey, Aberdeen, and Minidoka were considered background levels. Measurements of boundary community exposures were made at Atomic City, Howe, Arco, Butte City, Mud Lake, and Roberts. There was no evidence to suggest that any of the exposures at the NRTS boundary communities were different from background or were the result of NRTS activities.

Summary

The results of the air monitoring program for 1971 indicated that the increases in air concentrations offsite due to NRTS releases were indistinguishable from the natural radioactivity in air. When special techniques were used to measure the worldwide radioactive fallout (approximately 0.2 percent to 2 percent of the natural radioactivity in air) the sensitivity was high enough to indicate small releases of NRTS activity measurable above the worldwide fallout. The average increased exposure by airborne radioactivity just offsite was approximately 0.5 percent of the natural radon series and thoron series exposure in air. From identification of specific radionuclide concentrations none of the concentrations were greater than 0.09 percent of the appropriate standard as listed in the concentration guides of the U.S. Atomic Energy Commission's Manual Chapter 0524.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits of the analyses. The fission product levels in milk were similar to those reported in *Radiation Data and Reports* for the region and the source is believed to be fallout from nuclear weapons and not NRTS operations. Wheat samples collected at harvest also contained small

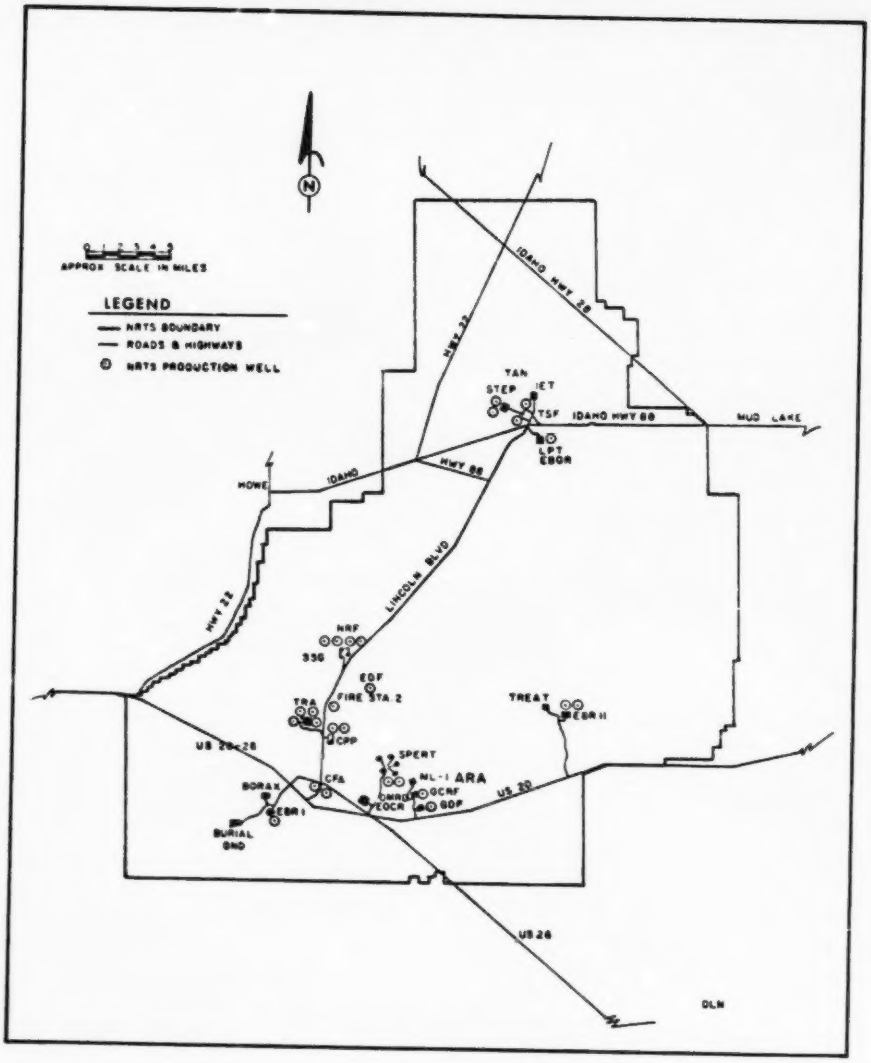

Figure 7. National Reactor Testing Station

amounts of strontium-90 from worldwide fallout.

Gamma radiation exposures were measured simultaneously at distant background locations and at communities near the NRTS boundary. There was no evidence that the exposures at the NRTS boundary communities were different from background.

REFERENCE

(6) HALLDEN and HARLEY. An improved alpha counting technique. Anal Chem 32:1861 (1960).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1970	December 1973

Nuclear Power Reactors in the United States
December 31, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports*.

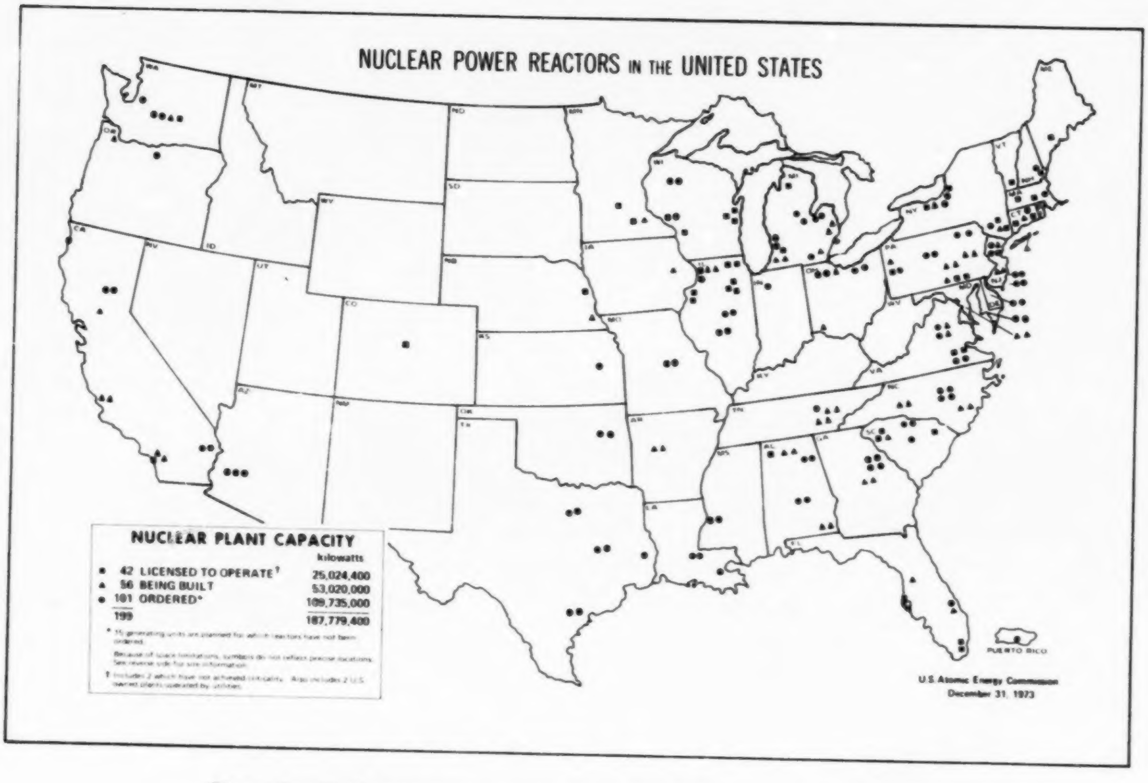
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
kilowatts
■ 42 LICENSED TO OPERATE† 25,024,400
▲ 56 BEING BUILT 53,020,000
● 101 ORDERED* 109,735,000
199 187,779,400
* 15 generating units are planned for which reactors have not been ordered.
Because of space limitations, symbols do not reflect precise locations. See reverse side for site information.
† Includes 2 which have not achieved criticality. Also includes 2 U.S. owned plants operated by utilities.
PUERTO RICO
U.S. Atomic Energy Commission
December 31, 1973

Figure 1. Nuclear power reactors in the United States, December 31, 1973

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1980
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1981
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,189,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,189,000	Tennessee Valley Authority	1980
Wintersburg		1,270,000	Arizona Public Service	1981
Wintersburg		1,270,000	Arizona Public Service	1982
Wintersburg		1,270,000	Arizona Public Service	1984
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1974
Russellville	Arkansas Nuclear One: Unit 2	912,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1980
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,084,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,106,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	913,000	Sacramento Municipal Utility District	1974
·		1,128,000	Pacific Gas & Electric Co.	1981
·		1,128,000	Pacific Gas & Electric Co.	1982
Needles	Eastern Desert Plant: Unit 1	770,000	Southern California Edison Co.	1981
Needles	Eastern Desert Plant: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1974
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1980
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1981
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 3	1,121,000	Georgia Power Co.	1982
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 4	1,121,000	Georgia Power Co.	1983
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad Cities Station: Unit 1	800,000	Comm. Ed. Co. Ia. Ill. Gas & Elec. Co.	1972
Cordova	Quad Cities Station: Unit 2	800,000	Comm. Ed. Co. Ia. Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co. Ia.	1978
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co. Ia.	1979
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1980
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1981
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant: Unit 1	955,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	955,000	Illinois Power Co.	1982
INDIANA				
Porter County	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1979
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	569,000	Iowa Electric Light and Power Co.	1974
KANSAS				
Burlington	Wolf Creek Generation Station: Unit 1	1,150,000	Kansas Gas & Electric - Kansas City P & L	1981
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1981
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972

Figure 1. Nuclear power reactors in the United States, December 31, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Nanjemoy	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Nanjemoy	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,172,000	Detroit Edison Co.	1981
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1976
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,200,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,200,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1982
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSOURI				
Fulton	–	1,150,000	Northern States Power Co.	1981
Fulton	–	1,150,000	Northern States Power Co.	1983
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,290,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,290,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1979
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Salem	Hope Creek Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Salem	Hope Creek Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1982
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
•	–	1,150,000	Public Service Electric and Gas, N.J.	1983
•	–	1,150,000	Public Service Electric and Gas, N.J.	1984
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	470,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
•		1,150,000	Long Island Lighting Co.	1981
Oswego	Sterling Nuclear: Unit 1	1,150,000	Rochester Gas & Electric Co.	1982
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1980
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1981
•		1,300,000	Duke Power Co.	1981
•	–	1,300,000	Duke Power Co.	1982
•	–	1,300,000	Duke Power Co.	1983
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 1	906,000	Toledo Edison-Cleveland El. Illum. Co.	1976
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 2	906,000	Toledo Edison-Cleveland El. [illegible] Co.	1981
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 3	906,000	Toledo Edison-Cleveland El. [illegible] Co.	1983
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	1,000,000	Cincinnati Gas & Electric Co.	1982

Figure 1. **Nuclear power reactors in the United States, December 31, 1973—continued**

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OKLAHOMA				
Inola	Black Fox Nuclear Station: Unit 1	950,000	Public Service of Oklahoma	1982
Inola	Black Fox Nuclear Station: Unit 2	950,000	Public Service of Oklahoma	1984
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman	—	1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1974
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1979
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1975
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1979
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1976
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1981
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
*	—	1,300,000	Duke Power Co.	1984
*	—	1,300,000	Duke Power Co.	1985
*	—	1,300,000	Duke Power Co.	1986
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Clinch River Breeder Reactor Plant	350,000	Project Management Corporation	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1980
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1980
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1976
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	882,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	882,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,206,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Satsop	WPPSS No. 3	1,242,000	Washington Public Power Supply System	1981
Sedro Woolley	Skagit Nuclear Project	1,200,000	Puget Sound Power & Light	1982
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
*	—	900,000	Wisconsin Electric Power Co.	1980
*	—	900,000	Wisconsin Electric Power Co.	1982
Durand	Tyrone Energy Park: Unit 1	1,150,000	Northern States Power Co.	1982
Durand	Tyrone Energy Park: Unit 2	1,150,000	Northern States Power Co.	1983
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979

* Site not selected.

*	—	1,128,000	Tennessee Valley Authority	1980
*	—	1,128,000	Tennessee Valley Authority	1981
*	—	1,128,000	Tennessee Valley Authority	1980
*	—	1,128,000	Tennessee Valley Authority	1981

Figure 1. Nuclear power reactors in the United States, December 31, 1973—continued

Reported Nuclear Detonations, February 1974

(Includes seismic signals presumably from foreign nuclear detonations)

There were no seismic signals recorded by the United States for February 1974.

The U.S. Atomic Energy Commission conducted an underground nuclear test at its Nevada Test Site on February 27, 1974. The test was in the yield range between 20 and 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOLOGICAL SURVEILLANCE AROUND TURKEY POINT, 1970–1971. *Wallace Johnson* and *Jearold Eakins. Radiation Data and Reports, Vol. 15*, March 1973, pp. 105–115.

Prior to the operation of the Turkey Point Nuclear Power reactor environmental media were sampled and data are presented for 1970–71. Basic media investigated includes air, precipitation, soil, silt, and water, including sea water.

A number of media utilized as indicator organisms serve to investigate the behavior of radionuclides in several ecological levels. Indicators are mangrove vegetation, fresh water algae, turtle grass and sponges. Additional items found in the human food chain that were analyzed include crustacea, fish, and food crops.

KEYWORDS: Air, crustacea, fish, food crops, Florida, preoperational survey, reactor, silt, soil, vegetation, water.

PREOPERATIONAL LEVELS OF ENVIRONMENTAL RADIOACTIVITY IN WATER AND SEDIMENT AROUND TURKEY POINT NUCLEAR POWER PLANTS, CARD SOUND, FLORIDA. *Tod S. Johnson and Thomas D. Pemble. Radiation Data and Reports, Vol. 15*, March 1974, pp. 116–123.

An investigation of the levels and distribution of gross alpha, gross beta and selected gamma-emitting radioisotopes present in water and sediment samples from Card Sound, Fla., was performed. This environmental radioactivity baseline study, was carried out between January 1971 and June 1972, prior to operation of the Turkey Point Nuclear Power Plants and discharge of liquid effluents from these plants into Card Sound.

KEYWORDS: Background radiation, Florida, reactor, sediment, water.